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Choosing Voting Systems behind the Veil of Ignorance:
A Two-Tier Voting Experiment

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Abstract

There are many situations in which different groups make collective decisions by committee voting, with each group represented by a single person. A natural question is what voting system such a committee should use. Concepts based on voting power provide guidelines for this choice. The two most prominent concepts require the Banzhaf power index to be proportional to the square root of group size or the Shapley-Shubik power index to be proportional to group size. Instead of studying the choice of voting systems based on such theoretical concepts, in this paper, I ask which systems individuals actually prefer. To answer this question, I design a laboratory experiment in which participants choose voting systems. I find that people behind the veil of ignorance prefer voting systems following the rule of proportional Shapley-Shubik power; in front of the veil subjects prefer voting systems benefiting their own group. Participants' choices can only partially be explained by utility maximization or other outcome based concepts.

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Keywords: assembly voting; EU council; Penrose's Square Root Rule; optimal voting rule

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1 Introduction

There are many situations in which different groups make a collective decision. If groups send one representative each and these representatives vote together, this is called two-tier voting. The best known case of such two-tier voting is probably the Council of the European Union, the main decision-making body of the EU (informally called the Council of Ministers). However, this is not the only institution that operates in this manner. Examples of other institutions in which such voting takes place are the UN General Assembly, the IMF, the WTO, the OPEC, the African Union, the German Bundesrat, the ECB, and thousands of boards of directors and professional and non-professional associations. Two-tier voting is present, in one form or another, in innumerable situations, and it may increase in importance in the future. Reasons why two-tier voting may become increasingly important are the emergence of democracy in many parts of the world and globalization, which makes collaboration in supra-national organizations increasingly necessary. Furthermore, modern communication technologies allow actors to organize even if they are geographically dispersed.

There is no agreement among the scientific community on the question of how voting systems in an assembly of representatives should be designed. Arguments on this topic peaked during the reformation of the EU voting system. Nine scholars wrote an open letter to the governments of the EU member states, cosigned by 38 other scholars, calling on the EU to implement Penrose's Square Root Rule (Penrose, 1946; Banzhaf III, 1964; the letter can be found at `http://www.esi2.us.es/~mbilbao/pdffiles/letter.pdf`). Some government officials had already favored such a rule, such as the Swedish government in 2000 and, most famously, the Polish government, which pushed heavily for such a rule in 2007. Despite considerable support, this rule faced opposition by leading scholars (see, e.g., Laruelle and Valenciano, 2008 or Turnovec, 2009).

There is a vast literature on theoretical rules about how voting systems should be designed and about how closely actual voting systems follow the different theoretical guidelines.[1] There is, however, no work investigating which voting systems for an assembly of representatives people actually prefer. This question is very important because the preference for voting systems and their acceptance are closely related. It is important for people to accept the voting systems that govern them. This applies not only to the EU, where politicians in Brussels and elsewhere are constantly concerned

[1]The literature on two-tier voting within the EU alone is too extensive to be listed here; among others, it includes Baldwin and Widgrén (2004), Beisbart et al. (2005), Felsenthal and Machover (2001), Felsenthal and Machover (2004), Laruelle and Valenciano (2002), Laruelle and Widgrén (1998), Le Breton et al. (2012), Leech (2002), Leech and Machover (2003), Napel and Widgrén (2006), Sutter (2000), and Turnovec (2009).

with the acceptance of EU institutions, but to all voting systems. I address this gap in the literature and provide the first research investigating which voting systems for an assembly of representatives people choose.

The two most prominent rules for how voting systems should be designed require either (i) that the Banzhaf power index of a representative of a group be proportional to the square root of the group's size (Penrose's Square Root Rule) or (ii) that the Shapley-Shubik power index of a representative of a group be proportional to the group's size.[2] Do people choose voting systems according to these concepts when they are behind the veil of ignorance – that is, when they do not know which group they will be in? If so, which of these rules do they prefer? Or do people maximize expected utility? I investigate these questions in a laboratory experiment with monetary incentives (in take-it-or-leave-it settings). In one treatment, efficiency concerns are absent, and the assumptions of the theoretical derivations of the rules are closely mimicked (meaning i.a. that a participant's preference over the voting outcome is independent of all other participants). In another treatment, paticipants' preferences over the voting outcome are perfectly correlated within a group. This variation allows to see in how far participants' choices are driven by utility maximization. Furthermore, this approach allows the observation of how stable the choices of participants are when the assumptions of the rules are violated.[3] The experimental design is such that expected utility maximization coincides with most other outcome-based concepts behind the veil of ignorance. Furthermore, in the control treatments, I examine whether choices differ in front of the veil of ignorance – that is, when subjects know which group they will be in.

To investigate which type of voting system people choose, a laboratory experiment is the obvious choice. In the laboratory, it is possible to put people behind the veil of ignorance. It is also possible to imitate the assumptions made in the derivations of the normative rules. Assumptions made in one treatment can then be modified in a controlled way, keeping everything else equal. Furthermore, laboratory experiments offer the possibility of incentivizing choices with monetary payments.

I obtain the following results. When efficiency concerns are absent, subjects behind the veil of ignorance prefer voting systems with proportional Shapley-Shubik power over voting systems designed according to Penrose's Square Root Rule. Voting systems designed according to Penrose's Square Root Rule are not chosen significantly more often

[2]Although these rules are the most prominent, they are not the only ones; see, e.g., Felsenthal and Machover (1999) or Le Breton et al. (2012).

[3]The normative rules are derived from particular examples but are applied very generally. Theoretical research shows that the rules can be sensitive to small changes in the assumptions (Kurz et al., 2013; Kaniovski, 2008). To some extent, one can see from this research if this also holds for individuals' choices.

than other voting systems that do not follow any reasonable rule. This is the case even if Penrose's Square Root Rule is given its best shot. Furthermore, when efficiency concerns are present, subjects still prefer systems exhibiting proportional Shapley-Shubik power over the other systems. These results can be seen as treatment differences between the behind-the-veil and the in-front-of-the-veil treatments. Participants in front of the veil predominantly choose the voting systems benefiting their own group, irrespective of which rules these systems follow. The results behind the veil of ignorance cannot be explained by utility maximization or other outcome-based behavior alone, supporting the claim that concepts based on voting power play a role in people's choices. Nevertheless, a difference in differences analysis shows that utility maximization or other outcome based considerations play at least some role.

This research is the first to examine which type of voting systems for an assembly of representatives people choose. It is also the first experiment on two-tier voting in general.[4]

This paper is organized as follows. In Section 2, the primary motivations in take-it-or-leave-it committee voting settings of the two main normative concepts for designing two-tier voting systems are outlined. Furthermore, the behavior of subjects who maximize expected utility is derived. Section 3 contains the experimental design and procedures. Section 4 contains the data analysis and results. Section 5 concludes the paper.

2 Theory: Equalizing Voting Power and Maximizing Utility

This section presents the two most prominent rules for how two-tier voting systems, i.e. voting systems for assemblies of representatives, should be designed, as well as their probabilistic motivations.[5] The underlying idea of both rules is that it should be equally likely for each individual to influence the outcome of the voting process in the assembly

[4]There are other experiments on voting power, namely Montero et al. (2008), Drouvelis et al. (2010), Aleskerov et al. (2009), Guerci et al. (2011), Esposito et al. (2012), and Geller et al. (2012). This research may have implications for two-tier voting, but it does not directly address it. Furthermore, the above-mentioned research is performed in bargaining settings that differ considerably from the take-it-or-leave-it settings used in this paper. Most experimental research on voting power addresses the question of how voting systems map to voting power. Moreover, there is related literature eliciting peoples' preferences for social choice rules that is not concerned with two-tier voting, such as Kara and Sertel (2005).

[5]The probabilistic motivations of these rules are described in a very similar way in Weber (2014).

of representatives (on which individuals have only indirect influence via the election of a representative). After presenting these rules, I show how utility maximizing agents choose voting systems in a take-it-or-leave-it two-tier voting setting.[6]

The following notation and definition will be used throughout the remainder of the paper. Coalitions are sets of voters voting in favor of adopting a proposal (yes-voters) or against it (no-voters) and are denoted by the capital letters S and T (I do not need to denote more than two coalitions at once). Assume that there are M voters, numbered from 1 to M. Then, a coalition is always a subset of $\{1,...,M\}$. Note that a voting system is fully characterized by the set of winning coalitions. Voting systems (i.e., sets of winning coalitions) are denoted by calligraphic letters. A voting system $\mathcal{W}$ is admissible if it satisfies the following conditions ($\mathcal{W}$ is thus a set of (winning) coalitions, which are subsets of 2^M): (i) $\{1,...,M\} \in \mathcal{W}$, (ii) $\emptyset \notin \mathcal{W}$, (iii) if $S \in \mathcal{W}$ then $S^C \notin \mathcal{W}$, and (iv) if $S \in \mathcal{W}$ and $S \subseteq T$ then $T \in \mathcal{W}$. In words, these conditions mean that the grand coalition (everyone voting for something) is always winning, and the empty coalition (no one voting for something) is always losing. If a coalition is winning, the complement is not winning (those not in a winning coalition cannot also form a winning coalition), and if a winning coalition gains additional support, it is still winning. The set of admissible voting systems contains any reasonable voting system. This set is larger than the set of all weighted voting systems – double majority systems, for example, as used in the EU Council of Ministers cannot, in general, be represented by weighted voting.

There are N different groups, numbered from 1 to N. Each group i consists of n_i individuals, numbered from 1 to n_i. Each group elects one representative through majority voting. The representatives then come together in an assembly to vote. They vote on an issue concerning all individuals in the best interest of their group. The voting system that should govern the voting in this assembly of representatives is the focus of most of the two-tier voting literature.[7]

The two rules outlined in this section were developed as normative rules. This paper investigates the choices people make; thus, it examines two-tier voting from a positive

[6] The vast majority of the literature on two-tier voting is not based on utility but on voting power. Although there may be agreement between utility and voting power considerations (particularly voting in bargaining committees), they are generally different. In take-it-or-leave-it settings, utility-based concepts have emerged only very recently (Barbera and Jackson, 2006; Beisbart et al., 2005; Koriyama et al., 2013; Laruelle and Valenciano, 2010). One reason the focus has been on voting power may be that it can be derived from a voting system alone without specifying utility. It may also be easier to estimate power by assessing how often certain groups get their way than by estimating utility gains.

[7] Often, the terms 'voting system' and 'voting rule' are used interchangeably. Here, I use 'voting rule' for an abstract rule describing voting systems, which can be applied in different situations, i.e., different numbers of groups and individuals per group (such as Penrose's Square Root Rule). I use the term 'voting system' when the number of groups and the number of individuals per group are fixed.

perspective. Proponents of these rules may claim that they never thought people would choose according to these concepts. Nevertheless, there is a clear connection between the normative side and the positive side. If people are put behind the veil of ignorance, do they choose voting systems recommended by these rules? If so, which of these concepts do they favor? How robust are their choices to violations of the assumptions underlying the theories?

2.1 Rule I: Penrose's Square Root Rule

The most prominent normative concept of how two-tier voting systems should be designed is the following:

Rule I (Penrose's Square Root Rule). *The voting power of (the representative of) a group as measured by the Banzhaf index should be proportional to the square root of its population size.*

The primary idea of this rule is to make it equally likely for every individual to influence the overall outcome of the two-tier voting procedure, independently of the group to which she belongs. The standard motivation of this rule derives from a particular setting, which is described briefly below.

First, I provide a few very brief definitions in accordance with the literature. If a coalition is not winning without voter j but is winning with her, we say that voter j has a swing. The absolute Banzhaf index of a voter j is defined as the number of possible winning coalitions that turn into losing coalitions without voter j divided by the total number of possible coalitions. The normalized or relative Banzhaf index is the absolute Banzhaf index normalized so that the sum of the indices of all voters equals one.

The particular set-up that is used to motivate Penrose's Square Root Rule is the following. Voting is binary; that is, a proposal can be either adopted or rejected. Every individual, no matter which group she belongs to, favors the adoption of a proposal with probability one-half, independently of all other individuals.[8] Majority voting takes place within each group, and the outcome determines the vote of the representative. Then, the representatives of all groups come together, and their votes and the voting system in the assembly determine whether a proposal is adopted or rejected.

Denote by Ψ_i^B the absolute Banzhaf power index of an individual in group i arising from majority voting in this group and by Φ_i^B the absolute Banzhaf power index of group i

[8]If every voter favors the adoption of a proposal with probability one-half independently of everyone else, the absolute Banzhaf index of a voter is the probability that this voter has a swing.

in the assembly of representatives, depending on the voting system in place. Then, the probability that an individual in group i has a swing with respect to the overall outcome of the voting procedure (i.e., that she influences with her vote within the group the overall outcome in the assembly of representatives) is Ψ_i^B times Φ_i^B. Thus, the probability of influencing the overall outcome is equal for all individuals if $\Psi_i^B \Phi_i^B$ is equal for all individuals or, equivalently, if

$$\Psi_i^B \Phi_i^B = \alpha \tag{1}$$

for some constant α and all i. Numbering groups from 1 to N and individuals in group i from 1 to n_i, it can easily be shown that equation (1) holds for all i if the normalized Banzhaf index of each group i is equal to

$$\frac{\frac{1}{\Psi_i^B}}{\sum_{j=1}^{N} \frac{1}{\Psi_j^B}}.$$

The normative rule for how to design voting systems described here states that the indirect voting power $\Psi_i^B \Phi_i^B$ should be equal for all individuals independently of which group they are in – that is, that equation (1) should hold. The reason that this is often referred to as square root rule is the following. Ψ_i^B in equation (1) can be approximated by $\sqrt{\frac{2}{\pi n_i}}$; thus, equation (1) holds if the Banzhaf indices of the groups are proportional to the square root of their sizes.[9]

The system of equations (1) does, in general, not hold exactly. The problem of approximating a distribution of voting power with an actual voting system is called the inverse power problem.[10] Here, I use two methods to address the inverse power problem, one classic method and a new method introduced in Weber (2014). The differences between the methods and the advantages of the new method are discussed in Weber (2014). In the experiment, I only use constellations in which both methods yield the same unique outcome. If one of the two methods is rejected on a theoretical basis, this has thus no consequences for the conclusions of the experiment.

[9] See, for example, Felsenthal and Machover (1998) or Laruelle and Widgrén (1998). The exact value is $\Psi_i^B = \frac{n_i!}{2^{n_i}((n_i/2)!)^2}$. Usually, researchers use the approximation, which is not a problem for applications in which the groups are countries that are large enough to make the approximation very good. Because the theory can also be applied to small groups, such as companies, boards, or clubs, it can sometimes be better to use the exact values. I will not use the approximation in this paper, but still talk about the Banzhaf index being proportional to the square root of group size (working with the exact value or the approximation makes no conceptual difference).

[10] This problem is far from trivial; see, for example, Alon and Edelman (2010), De et al. (2012), and Kurz and Napel (2014).

Note that it is possible to restrict the set of voting systems from which one system is selected that approximates equation (1) best. Such a subset of all admissible voting systems could, for example, be all weighted voting systems, all weighted voting systems satisfying some additional conditions, all double majority voting systems, or all voting systems with a certain number of winning coalitions. Denote by $\mathbf{V}$ the set of all admissible voting systems and by $\mathbf{W} \subseteq \mathbf{V}$ a subset from which we want to select the voting system that best approximates Rule I, and define $\overline{\Psi^B\Phi^B} := \frac{1}{\sum_{i=1}^N n_i}\sum_{i=1}^N n_i\Psi_i^B\Phi_i^B$. Then, the following formulas are available to select the voting systems approximating Rule I (now explicitly writing down the dependence of Φ on the voting system $\mathcal{W}$).

Method 1. *Using a classic method of minimizing the squared deviation from the desired vector of normalized Banzhaf indices per group (weighted by group size), the recommended voting system is*

$$\mathcal{V}_{PB,classic} = \underset{\mathcal{W}\in\mathbf{W}}{\arg\min} \sqrt{\frac{1}{\sum_{i=1}^N n_i}\sum_{i=1}^N n_i\left(\frac{\Phi_i^B(\mathcal{W})}{\sum_{i=1}^N \Phi_i^B(\mathcal{W})} - \frac{\frac{1}{\Psi_i^B}}{\sum_{i=1}^N \frac{1}{\Psi_i^B}}\right)^2}. \tag{2}$$

Method 2. *Using a recent method of minimizing the coefficient of variation of indirect voting power (as measured by the Banzhaf index), the recommended voting system is*

$$\mathcal{V}_{PB,recent} = \underset{\mathcal{W}\in\mathbf{W}}{\arg\min} \frac{\sqrt{\frac{1}{\sum_{i=1}^N n_i}\sum_{i=1}^N n_i\left(\Psi_i^B\Phi_i^B(\mathcal{W}) - \overline{\Psi^B\Phi^B(\mathcal{W})}\right)^2}}{\overline{\Psi^B\Phi^B(\mathcal{W})}}. \tag{3}$$

2.2 Rule II: Proportional Shapley-Shubik Power

Another prominent normative concept for the way two-tier voting systems should be designed is as follows. Much of the derivation for the probabilistic motivation of this rule can be performed similarly to Section 2.1. This explanation is thus very brief.[11]

Rule II (Proportional Shapley-Shubik Power). *The voting power of (the representative of) a group as measured by the Shapley-Shubik index should be proportional to its population size.*

In contrast to the derivation of Penrose's Square Root Rule, it is now assumed that all voters differ in the strength of their feelings over the issue at stake. One can then order all voters from strong preference to strong dislike. In general, voter j is in a

[11]The probabilistic motivation is not the only motivation for this rule; it can also be motivated in a bargaining committee setting. The Shapley-Shubik index originates from cooperative game theory (Shapley and Shubik, 1954, Shapley, 1953).

pivotal position if the coalition of voters that would like the adaption of a proposal more strongly than voter j does not have the power to pass it, whereas the coalition of voters that would like the adoption of the proposal less (dislike it more) does not have the power to block it. A voter in a pivotal position is thought to have decisive influence over the outcome of the voting process.

I now state the relevant definitions, in accordance with the literature. Let $(i_1, ..., i_M)$ be a permutation of voters (voters are numbered from 1 to M; the voting system – i.e., the set of winning coalitions – is denoted by $\mathcal{W}$). If voter j's position in the permutation is i_k, then voter j is pivotal if $\{i_1, ..., i_{k-1}\} \notin \mathcal{W}$ and $\{i_1, ..., i_k\} \in \mathcal{W}$. The Shapley-Shubik power index of voter j is the number of permutations in which j is pivotal divided by the total number of permutations $M!$. Note that the sum of the Shapely-Shubik indices of all voters equals one and that this index represents the probability of being pivotal if all permutations (that can be seen as preference orderings) are equally likely.

Denote by Ψ_i^S the Shapley-Shubik power index of an individual in group i arising from majority voting and by Φ_i^S the Shapley-Shubik index of group i in the assembly of representatives, depending on the voting system in the assembly. Assuming that all permutations are equally likely in both stages of the voting procedure, the probability that an individual in group i is pivotal in the first stage while the representative of group i is pivotal in the second stage is $\Psi_i^S \Phi_i^S$. Then, the probability of influencing the overall outcome is equal for all individuals if

$$\Psi_i^S \Phi_i^S = \alpha \tag{4}$$

for all i and some constant α. Because the Shapley-Shubik indices of all voters sum to one, it is $\Psi_i^S = \frac{1}{n_i}$. Thus, equation (4) holds for all i if the Shapley-Shubik index of each group i is equal to $\frac{n_i}{\sum_{j=1}^N n_j}$, i.e., if the Shapley-Shubik indices of the groups are proportional to their sizes.

Here, the system of equations (4) in general does not hold exactly. Proceeding as in Weber (2014), one arrives at the following two methods (except for the superscripts, the formulas are identical to the formulas in Section 2.1):

Method 1. *Using a classic method of minimizing the squared deviation from the desired vector of normalized Shapley-Shubik indices per group (weighted by group size), the recommended voting system is*

$$\mathcal{V}_{SS,classic} = \underset{\mathcal{W} \in \mathbf{W}}{\arg\min} \sqrt{\frac{1}{\sum_{i=1}^N n_i} \sum_{i=1}^N n_i \left(\frac{\Phi_i^S(\mathcal{W})}{\sum_{i=1}^N \Phi_i^S(\mathcal{W})} - \frac{\frac{1}{\Psi_i^S}}{\sum_{i=1}^N \frac{1}{\Psi_i^S}} \right)^2}. \tag{5}$$

Method 2. *Using a recent method of minimizing the coefficient of variation of indirect voting power (as measured by the Shapley-Shubik index), the recommended voting system is*

$$\mathcal{V}_{SS,recent} = \underset{\mathcal{W}\in\mathbf{W}}{\arg\min} \frac{\sqrt{\frac{1}{\sum_{i=1}^{N} n_i}\sum_{i=1}^{N} n_i \left(\Psi_i^S\Phi_i^S(\mathcal{W}) - \overline{\Psi^S\Phi^S(\mathcal{W})}\right)^2}}{\overline{\Psi^S\Phi^S(\mathcal{W})}}. \tag{6}$$

2.3 Choosing Voting Systems According to Expected Utility Theory

Sections 2.1 and 2.2 show recommendations for how voting systems should be designed. Now, I derive the way that utility maximizing individuals choose voting systems in a setting that can be applied one-to-one to the experiment.

To be able to derive predictions for which voting systems for the assembly of representatives utility maximizing individuals would choose, it is necessary to specify payments. The most natural payment specification is a fixed payment to an individual if the overall voting outcome coincides with the preferences of this individual over the voting outcome.[12] Without loss of generality, one can assume that a particular individual has a utility function u, which can be scaled so that utility is one if the individual is paid and zero otherwise.

We assume that only one issue is voted on. Because we assume majority voting at the group level and that the representative acts in the best interest of her group, individuals can only influence their own (expected) payment by choosing the voting system (because only one system is selected for payment, it is best to always choose the system that has the highest expected payoff; risk aversion does not play a role, and hedging is not possible).

In general, different interpretations of the veil of ignorance are possible. The interpretation that is appropriate for this experiment is unambiguous: being behind the veil of ignorance means not knowing which group one will be in and, more precisely, not knowing which individual one will be. Each individual is in the i-th group g_i with probability proportional to its size, $p(g_i) = \frac{n_i}{\sum_{i=1}^{N} n_i}$. These probabilities are known.

If $\mathbf{W}$ denotes the set of voting systems from which the individual can choose and u denotes her utility after the voting procedure is conducted (once), a utility maximizing agent chooses a voting system as follows (being successful means that the outcome

[12]In the experiment, individuals who are in favor of adopting a proposal in the experiment obtain a payment of 1000 points (12.50 euros) if the proposal is adopted and a payment of 0 otherwise. Individuals in favor of rejecting a proposal obtain a payment of 1000 points if the proposal is rejected and 0 otherwise.

preference of an individual coincides with the actual overall voting outcome):

$$\mathcal{V}_{B,max} = \underset{\mathcal{W}\in\mathbf{W}}{\arg\max}\ E(u|\mathcal{W}) = \underset{\mathcal{W}\in\mathbf{W}}{\arg\max}\sum_{i=1}^{N} p(g_i)\ p(\text{`}individual\ of\ g_i\ successful'|\mathcal{W}). \tag{7}$$

This means that a utility maximizing individual in the experiment chooses the most efficient voting system. The probability of success for an individual in a certain group depends on the voting system as well as on how preferences are formed. The assumption of independently drawn voting outcome preferences for each individual (where everyone is equally likely to favor the adoption or rejection of a proposal independently of everyone else) can be used as well as any other specification of probabilities or correlation structures. Given a voting system and the assumptions governing the probability distribution, the expected utility can always be calculated (or simulated).

This choice would be made by a utility maximizing economic agent and – in case that the voting procedure is only performed once (i.e., only one issue is voted on) – by someone with other reasonable outcome-based preferences (exhibiting, e.g., altruism or aversion to inequality). At the same time, this choice would be made by a social welfare maximizer that has a utilitarian social welfare function or, in fact, any other reasonable welfare function. This can be seen as follows. Only one issue is voted on, and only one voting system will be used; thus, each individual ends up with utility of either one or zero. Therefore, any reasonable outcome based rule chooses the voting system in which, in expectation, most people end up being successful.

In front of the veil of ignorance, a utility maximizing agent chooses the voting system that maximizes the expected utility of any member of the group that this agent will be in. Thus, an individual who knows that she will be in group j chooses the voting system according to

$$\mathcal{V}_{F_j,max} = \underset{\mathcal{W}\in\mathbf{W}}{\arg\max}\ E(u_j|\mathcal{W}) = \underset{\mathcal{W}\in\mathbf{W}}{\arg\max}\, p(\text{`}individual\ of\ g_j\ successful'|\mathcal{W}), \tag{8}$$

where u_j denotes the utility of an individual of group j after the voting process has been conducted. Here, even if only one issue is voted on, the choice of a utility maximizer in general does not coincide with the choices of individuals with different outcome-based preferences or with the choice of a utilitarian social welfare maximizer.

3 Experimental Design and Procedures

The experiment was conducted at the CREED laboratory at the University of Amsterdam with a total of 223 subjects recruited from the CREED subject pool. Participants were primarily undergraduate students, slightly less than half were female, and approximately 60% were majoring in economics or business. The experiment was programmed in PHP/MySQL. Four sessions were conducted, one for each treatment. A pilot with 17 subjects was conducted shortly before.[13] Every participant received 12 euros independently of the choices and outcomes of the experiment. During the experiment, 'points' were used as currency. These points were exchanged for euros at the end of each session at an exchange rate of 1 euro per 80 points. The experiment lasted between 60 and 90 minutes, and participants earned, on average, approximately 17.20 euros. Before starting, the participants had to answer control questions to make sure that they understood the instructions. The experiment did not begin until all participants had successfully answered these questions. Subjects received no information during the experiment on the choices of other subjects. Appendix A provides the instructions and test questions.[14]

3.1 Illustration of Voting Systems

In the experiment, subjects chose between different voting systems. These voting systems primarily represented the rules described in the previous section. Subjects were not familiarized with the theories underlying these voting systems. They did not choose between theoretical concepts but between actual voting systems in specified situations. As mentioned, a voting system in a fixed environment is fully determined by the set of winning coalitions. When choosing, subjects only saw neutral graphical representations of the sets of winning coalitions. Subjects' choices thus did not depend on how convincingly the motivations for the rules were explained or on whether subjects really grasped the concepts underlying these rules.

[13]The pilot was very similar to the actual sessions but involved some computer players because it was conducted with fewer subjects than needed for the actual sessions. After the pilot, the instructions were changed, and the exchange rate was adjusted slightly.

[14]The experimental sessions consisted of two parts. Subjects received no information regarding the second part before the first part was completed. In this paper, I only refer to the first and main part of the experiment. The sessions including both parts lasted approximately 30 minutes longer, and subjects earned, on average, 5.30 euros more than the numbers reported in the main text. Part 2 of the experiment addressed the willingness to pay to implement voting systems; reporting on this part of the experiment would go beyond the scope of this paper. I am not aware of any conclusions that can be drawn from the second part that would interfere with the conclusions from the main part. More information on the second part is available on request.

Figure 1 shows a screenshot of a decision situation in the experiment in which two voting systems – large rectangles – are shown (this figure shows the 'smallest' voting systems used in the experiment). Here, there are four groups: green, red, blue, and yellow. The number of individuals per group is indicated by the number of circles. Thus, the green group has 19 members, the red group has 15, the blue group has 3, and the yellow group also has 3. I now use the voting system on the left side as example. Each row represents a winning coalition. Thus, the first row indicates that if the green, red, and blue groups vote in favor of a proposal, the proposal will be adopted; the second row indicates that if green, red, and yellow vote in favor of a proposal, it will be adopted; and the third row indicates that if green, blue, and yellow vote in favor of a proposal, it will be adopted. The rows shown are all the winning coalitions, except for the grand coalition. The grand coalition is obviously always successful and is never shown so that the graphs are not too crowded. In the left voting system of this figure, as a further example, if only the red and the blue groups vote in favor of the adoption of the proposal, the proposal will not be adopted; there is no row showing only the red and the blue group.

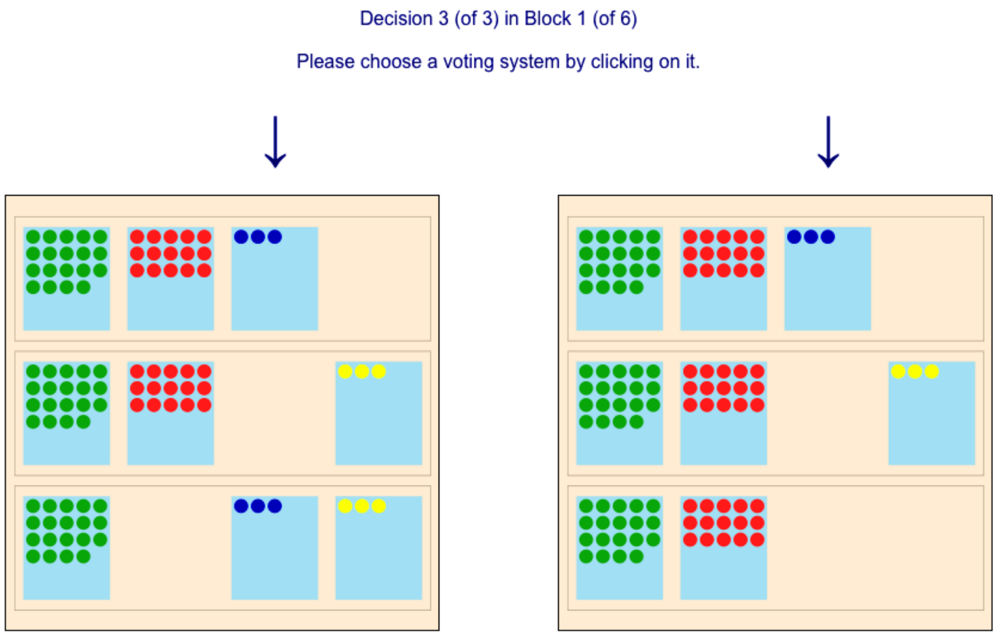

Figure 1: Screenshot in Front of the Veil

Notes: This screenshot is from a treatment in front of the veil (there is an arrow indicating which group the participant will be in). The rows of the graphs are exhaustive lists of winning coalitions, omitting the grand coalition. The voting systems shown here are the 'smallest' ones used in the experiment (four groups and four winning coalitions, three without the grand coalition).

3.2 Treatments and Overview

The experiment uses a setting of take-it-or-leave-it voting, meaning that the assembly of representatives votes directly on proposals.[15] Depending on the outcomes of a random draw, group members prefer the proposal to be adopted or rejected (the law governing the random draw depends on the treatment). The set-up of the experiment and its incentives leave no room for strategic voting considerations or abstentions.

The design is primarily a 2×2 factorial between subject design. Subjects are either behind the veil of ignorance (i.e., when they make a choice they do not know which group they will be in if this choice will be selected for payment) or in front of the veil of ignorance (i.e., they do know which group they will be in). The other dimension of the 2×2 design determines how preferences over the final outcome of the voting stage are formed. While the ex ante probability of favoring the adoption of the proposal is always one-half, these outcome preferences are either drawn independently for each participant or they are drawn independently at the group level (in which case these preferences are fully aligned within a group). Table 1 gives an overview of the design.

Table 1: 2×2 Between Subjects Design

	Independent preferences	Aligned preferences
Behind the veil	*BI* (54)	*BA* (54)
In front of the veil	*FI* (58)	*FA* (57)

Notes: The cells show the acronyms used for the between subjects treatments (and the numbers of observations). Subjects are either behind the veil of ignorance (B) or in front of the veil (F). Voting outcome preferences are either drawn independently for each participant (I) or are drawn independently at the group level and thus aligned within a group (A).

This is the simplest overview of the design. There are also features of a within subjects design; in each of these treatments, subjects are shown six different blocks of decision situations (with 18 choices overall). Furthermore, when looking at the treatments in front of the veil, it is usually reasonable to split the data according to the group to which subjects belong.

[15] Most of the literature refers to the adoption or rejection of a proposal. Therefore, I use these terms in this paper. In the experiment, to avoid leaving subjects wondering about the content of this mysterious proposal, the framing used is binary voting on X or Y, where Y is the outcome if no winning coalition of X-supporters can be formed.

3.3 Decision Situations

There are six different blocks in which subjects choose between different voting systems. The number of groups (either four or five) and the number of individuals per group are fixed within a block. In each block, there is one voting system representing Rule I (Banzhaf index proportional to the square root of the group size), one voting system representing Rule II (Shapley-Shubik index proportional to the group size), and one competing voting system that is different but not determined by any particular rule. Subjects always have the choice between two voting systems. Thus, there are three decisions per block (Rule I - Rule II, Rule I - competitor, Rule II - competitor). Any voting system that a participant chooses may be subsequently selected for payment. The order in which the blocks appear is random to avoid order effects.[16] Furthermore, the order of the three comparisons within each block is random, as is which voting system appears on the left side of the screen and which appears on the right side. Figures 1 and 2 show screenshots of the decision situations.

The screenshot in Figure 1 is taken from a treatment in front of the veil. The participant can thus see an arrow indicating which group she will be in if her choice is selected for payment. In the example shown, she will be in the blue group. The decision block shown in Figure 1 is the least complex block, with four groups and four winning coalitions (three without the grand coalition). The screenshot in Figure 2 is taken in a behind-the-veil treatment; thus, there is no arrow indicating which group the participant will be in for payment. The screenshot is from the block with the most complex decisions, i.e., with the largest rectangles: five groups and eight winning coalitions (seven without the grand coalition).

The different voting systems used in the experiment are shown in Table 2. The table shows the voting systems in the form of the sets of winning coalitions, which correspond to Rule I, Rule II, and a competing voting system that does not follow any particular rule. As in the graphical illustrations, the grand coalition is always omitted. The table also shows the number of groups and the number of individuals per group for each of the six decision blocks.

Table 3 shows the efficiency of the voting systems in the treatment *BA*, i.e., the probability of being successful (having a preference over the outcome of the voting procedure that coincides with the actual outcome) for an individual behind the veil. The efficiency in treatment *BI* is not shown because it is extremely similar for all voting systems in

[16] Although the a priori probability that each block is shown at any of the six positions is equal, the first three and last three blocks shown to a participant always have the same number of groups to avoid complicating the situation for the participants.

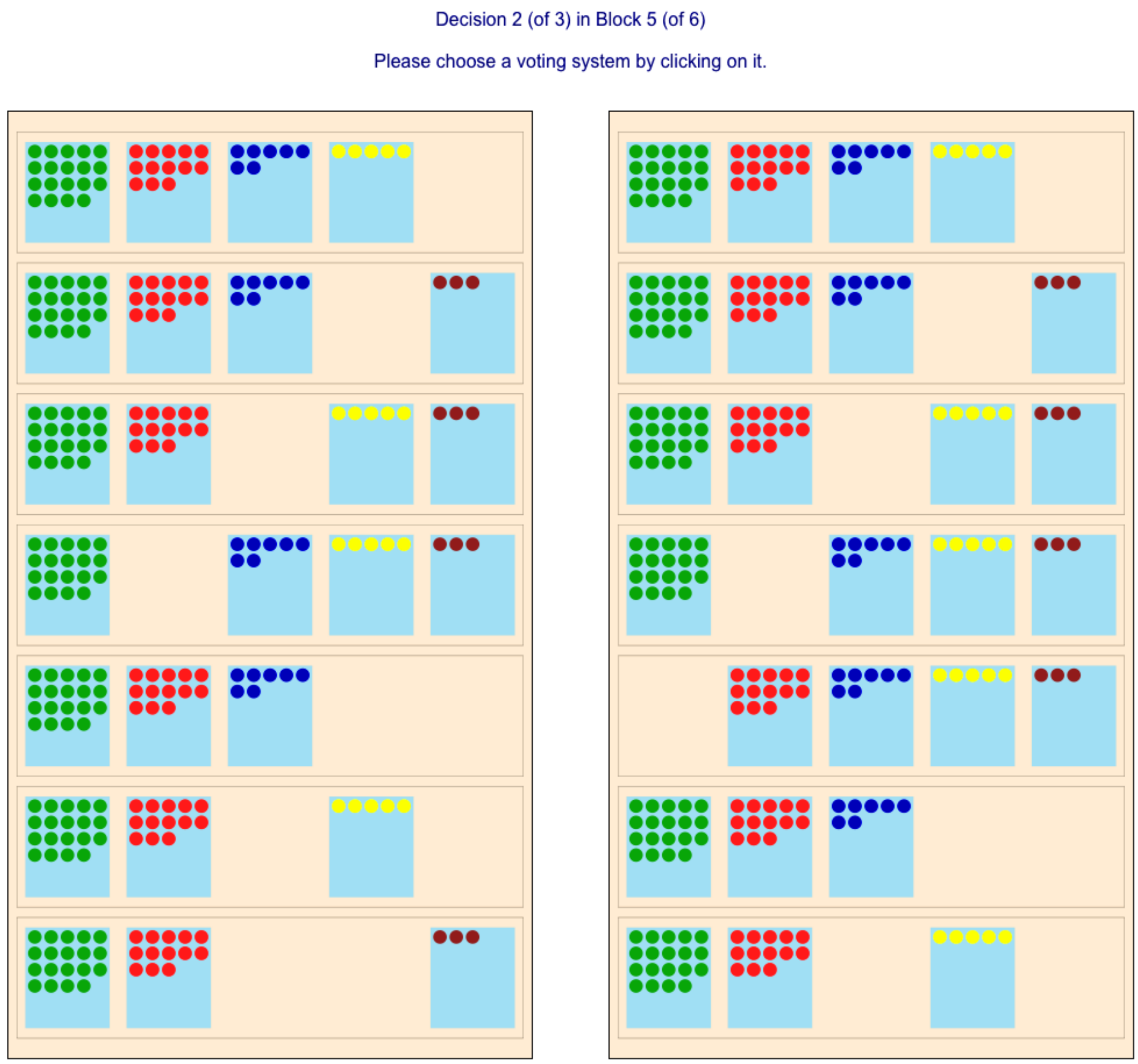

Figure 2: Screenshot behind the Veil

Notes: This screenshot is from a behind-the-veil treatment (no arrow indicating which group the participant will be in). This decision block is the most 'complex' one, i.e., the voting systems shown here are the 'largest' ones (five groups, eight winning coalitions – seven without the grand coalition).

a block.[17] More properties of these decision situations and the voting systems, such as efficiency for the treatments in front of the veil and power indices, can be found in Appendix B.1.

[17]In the experiment, efficiency differences in treatment *BI* are usually much less than one percent and never much more. Simulations have been used to arrive at all efficiency values. For each one, the voting procedure (including the preference formation) was simulated two million times.

Table 2: Voting Systems in the Decision Blocks

		Sets of winning coalitions		
Block #	Groups (size)	Rule I	Rule II	competitor
1	A(19), B(15), C(3), D(3)	{A,B,C}, {A,B,D}, {A,C,D}	{A,B,C}, {A,B,D}, {A,B}	{A,B,C}, {A,B,D}, {B,C,D}
2	A(21), B(7), C(5), D(3)	{A,B,C}, {A,B,D}, {A,C,D}, {B,C,D}, {A,B}	{A,B,C}, {A,B,D}, {A,C,D}, {A,B}, {A,C}	{A,B,C}, {A,B,D}, {A,C,D}, {A,C}, {A,D}
3	A(27), B(9), C(5), D(3)	{A,B,C}, {A,B,D}, {A,C,D}, {B,C,D}, {A,B}, {A,C}	{A,B,C}, {A,B,D}, {A,C,D}, {A,B}, {A,C}, {A,D}	{A,B,C}, {A,B,D}, {A,C,D}, {B,C,D}, {A,C}, {A,D}
4	A(15), B(13), C(11), D(5), E(1)	{A,B,C,D}, {A,B,C,E}, {A,B,D,E}	{A,B,C,D}, {A,B,C,E}, {A,B,C}	{A,B,C,D}, {A,C,D,E}, {A,C,D}
5	A(17), B(15), C(7), D(5), E(5)	{A,B,C,D}, {A,B,C,E}, {A,B,D,E}, {A,C,D,E}	{A,B,C,D}, {A,B,C,E}, {A,B,D,E}, {A,B,C}	{A,B,C,E}, {A,C,D,E}, {B,C,D,E}, {B,C,E}
6	A(19), B(13), C(7), D(5), E(3)	{A,B,C,D}, {A,B,C,E}, {A,B,D,E}, {A,C,D,E}, {B,C,D,E}, {A,B,C}, {A,B,D}	{A,B,C,D}, {A,B,C,E}, {A,B,D,E}, {A,C,D,E}, {A,B,C}, {A,B,D}, {A,B,E}	{A,B,C,D}, {A,B,C,E}, {A,B,D,E}, {A,B,C}, {A,B,D}, {A,B,E}, {A,B}

Notes: For each of the six decision blocks, the table shows the groups, their sizes, and the sets of winning coalitions (the voting systems) according to Rule I, Rule II, and a competitor that does not follow a particular rule. The grand coalition is always omitted. More details on the different voting systems and decision blocks can be found in Appendix B.1.

3.4 Voting Procedures and Payments

At the end of the experiment, one of the decisions of one participant is selected for payment. The participants are then distributed over the groups involved in the selected

Table 3: Efficiency of the Voting Systems in Treatment *BA*

	Block 1	Block 2	Block 3	Block 4	Block 5	Block 6
Rule I	0.684	0.722	0.756	0.601	0.616	0.663
Rule II	0.713	0.760	0.793	0.608	0.622	0.673
competitor	0.672	0.747	0.739	0.586	0.581	0.670

Notes: This table shows the efficiency, i.e., the probability of success for an individual behind the veil, of the voting systems when outcome preferences are aligned within groups.

decision situation. It is equally likely for each participant to be any of the individuals.[18] In the treatments in front of the veil, the participant whose choice is selected for payment is in the group that was indicated to her in the selected decision situation by an arrow. After the participants are distributed over the groups, their preferences over the overall voting outcome are determined. As noted above, ex ante, it is equally likely for each participant to favor the adoption or the rejection of the proposal. In treatments *BI* and *FI*, these voting outcome preferences are randomly drawn for each participant independently of all other participants. In treatments *BA* and *FA*, the outcome preferences are always aligned within a group (i.e., either all members of a group favor the adoption of a proposal or all favor its rejection).

Then, the voting procedure takes place. This voting procedure is fully automated. The (computerized) representative of each group votes in the best interest of its group. This means that in the treatments with independent outcome preferences, the representative votes according to the outcome preference of the majority of the group; in the other treatments, the representative votes according to the unique outcome preference of all group members. All groups have an odd number of members so that ties are not possible. Whether the proposal is adopted or rejected then depends on the votes of the representatives and on the voting system in place. Note that two assumptions usually made in the literature are fully automated: the assumption that the majority decides at the group level and the assumption that the representative of a group sticks to the decision of a group (these two assumptions can be collapsed into saying that 'the representative acts in the best interest of her group'). Then, each member of any of the groups is paid according to the following rule: if the overall outcome of the voting procedure coincides with the outcome preference of the participant, the participant receives 1000 points; otherwise, the participant receives nothing.[19]

[18]The decision situations do not require equal numbers of participants. Some subjects are thus not part of any of the groups and do not receive any payment.

[19]The way payments for the experiment are designed ensures that hedging is not possible for participants and that predictions of utility maximization coincide with other utility and outcome-based choices/preferences (see Section 2.3).

3.5 Relationship between Theory and Treatments

The experimental set-up is such that Rule I obtains its best shot in treatment *BI*. There, all assumptions made in the derivation of this rule are satisfied (and the most natural extension for payments is chosen). This treatment is less favorable to Rule II. One cannot really talk about an intensity of choice; thus, it is questionable whether it is reasonable to focus on the pivotal position as described in Section 2.2.[20] One could thus say that Rule I is somehow given an advantage over Rule II in treatment *BI* (because all of its assumptions have been implemented, whereas they are not completely fulfilled for Rule II). Under group aligned preferences, the assumptions of neither rule are totally fulfilled. These treatments are nevertheless important; keep in mind that these rules have been proposed many times as solutions for real-world problems in which the assumptions are very far from being fulfilled. It is thus also of interest to see which rule is chosen more often when the assumptions are relaxed (which allows some inferences to be drawn regarding the extent to which the rules correspond to some intuitive concept of fairness/optimality of voting systems). Furthermore, these treatments bring efficiency differences into play, which are basically absent in treatment *BI*. The competing voting systems that do not follow any reasonable rule can be used to check whether the voting systems according to one of the rules have real support in treatment *BI* and whether they are chosen more often than those without any foundation. The treatments in front of the veil serve as a control to determine whether and how choices differ when subjects know which group they will be in.

3.6 Selection of the Decision Situations Used in the Experiment

It is not trivial to find voting systems that correspond closely to the normative rules used. In Section 2, I have stated two methods to address this problem. All voting systems corresponding to one of the rules in this experiment correspond to this rule according to both methods. Thus, even if one of these methods is rejected, the conclusions from the experiment do not lose their validity. To find suitable decision situations, a computer program reviewed (a subset of) all admissible voting systems for all types of possible group compositions. I explain the selection procedure here briefly; further information can be found in Appendix B.2.

[20]Rule II can also be motivated axiomatically in a bargaining committee setting, which is different from the settings of the experiment and has no direct implication for it. This motivation might play a role if it is somehow connected to people's intuitive feeling of fairness in two-tier voting, but as such, it does not conflict with any of the conclusions of this paper.

To select the decision situations, only groups with an odd number of members were considered to avoid ties within groups. Furthermore, the groups cannot be too large because they must be used for a laboratory experiment (the CREED laboratory is large enough to handle up to 58 subjects). All constellations have either four or five different groups. The number of groups and the number of individuals per group are constant in a decision block, as is the number of winning coalitions (the voting system that corresponds best to a rule is thus always selected out of all admissible voting systems with a fixed number of winning coalitions).[21] Holding the number of winning coalitions constant makes it impossible for participants to choose according to the simple but good heuristic of always taking the system with the most winning coalitions. All of the different decision situations were selected in such a way that the recommended rules are the same according to both methods and different from each other and such that each system does not perform very well in terms of the other rule. Furthermore, a competitor, i.e., a voting system not prescribed by any reasonable normative rule, is added that does not perform well according to either rule.

4 Results

First, I present results for which voting systems subjects behind the veil of ignorance choose. Then, I examine whether subjects' decisions behind the veil can be explained with utility maximizing or other outcome based behavior. Finally, I investigate whether being behind or in front of the veil of ignorance makes a difference in this experiment and what drives choices in front of the veil. I present the results in this way to make it easy to understand and take away the main findings of the paper. The first and the third results correspond to treatment differences between the behind-the-veil and the in-front-of-the-veil treatments (differences in choices between these treatments are statistically highly significant as shown in Section 4.3; while subjects choose to their own benefit in front of the veil, they predominantly choose voting systems exhibiting proportional Shapley-Shubik power behind the veil). The second result corresponds to treatment differences between the independent outcome preference and the aligned outcome preference treatments behind the veil of ignorance.

Subjects in the experiment receive no information on others' decisions; thus, observa-

[21]The number of winning coalitions has sometimes been called 'efficiency' in the literature, going back to Coleman's 'power of a collectivity to act' (Coleman, 1971). Referring to the number of winning coalitions as 'efficiency' is avoided in this paper because it is not really efficiency, i.e., some form of expected sum of payoffs. The number of winning coalitions is sometimes a good approximation of efficiency, which is probably the source of this unfortunate denotation in the literature.

tions can be treated as statistically independent. Only non-parametric tests are shown because these draw upon less restrictive assumptions concerning underlying distributions than parametric tests. All tests performed are two-sided. The number of observations is 54 in treatments *BI* and *BA*, 58 in *FI*, and 57 in *FA*. Additional graphs and data can be found in Appendix B.3.[22]

4.1 Subjects Prefer Rule II (Proportional Shapley-Shubik Power) over Rule I (Penrose's Square Root Rule)

The primary research question of this paper is which type of voting systems subjects choose behind the veil of ignorance. Do they prefer voting systems according to Rule I, according to Rule II, or do they not choose according to either of these two rules?

A good way to summarize the data of the behind-the-veil treatments is to examine how many participants predominantly choose one voting system. Each participant makes 18 choices overall, and each of the three types of voting systems is involved in 12 of these choices. Figure 3 shows how many participants in treatments *BI* and *BA* choose a particular system at least 9 out of 12 times (considering 10 or 11 out of 12 choices provides a similar picture; this can be seen in Appendix B.3, Figure 23). One can see that in both treatments, there are many more subjects who overwhelmingly choose the Rule II voting system than subjects who overwhelmingly choose the Rule I voting system (the participants choosing predominantly for the competitor are probably primarily noise).

Figure 4 shows participants' choices in more detail. Because there are six blocks, each participant chooses between voting systems according to two particular rules six times. Now, we consider how often one of the rules is preferred. This yields for each participant and each comparison between two rules a number between 0 and 6, where 3 means that each rule has been chosen equally often in the direct comparison (0 means that the first mentioned rule – Rule I in 'R1-R2' and 'R1-c', Rule II in 'R2-c' – has never been chosen over the second mentioned rule; 6 means that the first mentioned rule has always been chosen). Figure 4 shows a bar for each participant and for each direct comparison between two rules, indicating how often each of the rules has been chosen

[22]The experiment is quite complex for the subjects. Because this complexity could be foreseen before the experiment was conducted, the questionnaire contained a question asking how choices were made, with the possibility of answering that the choices were made 'more or less randomly'. I use the full data set in general, but at points, I also refer to the data excluding subjects who chose randomly (these data do not contradict the results of the full data). The data without participants who answered that they chose 'more or less randomly' contain fewer observations, namely, 35 (*BI*), 32 (*BA*), 40 (*FI*), and 35 (*FA*).

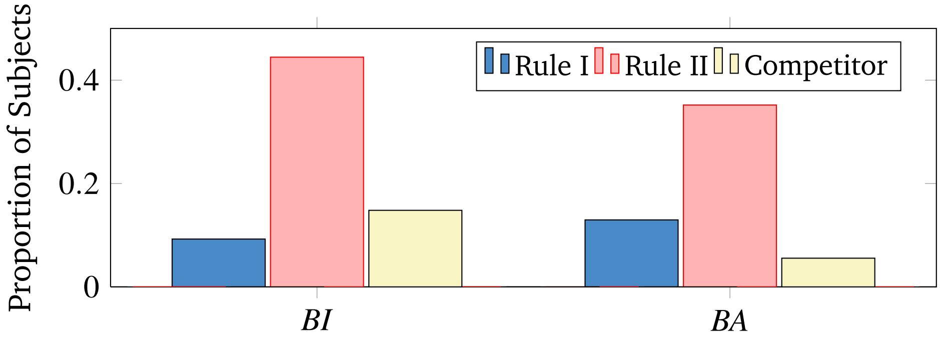

Figure 3: Proportion of Participants Choosing One System Predominantly

Notes: The figure shows the proportion of participants who choose a type of voting system at least 9 out of 12 times in treatments *BI* and *BA*.

over the other.[23]

I use Wilcoxon signed-rank tests to determine whether the differences in choices are statistically significant. The p-values are shown in the figure. The null hypothesis of the tests is that there is no difference in how often the voting systems according to the two compared rules have been chosen. Thus, the voting systems of Rule II are chosen significantly more often than the systems of Rule I in both treatments, *BI* and *BA*. Rule II voting systems are also chosen significantly more often in both treatments over the competing voting systems. Rule I voting systems are chosen significantly more often than the competing voting systems not following any particular rule only in treatment *BA*. Thus, the following result is obtained:

Result 1. *Participants behind the veil of ignorance prefer voting systems according to Rule II over voting systems according to Rule I. This preference exists both when efficiency concerns are absent and when such concerns are present.*

As explained in Section 3.5, the cleanest scenario to test the preference between the two rules is treatment *BI*. In this treatment, efficiency concerns are absent because all systems are basically equally efficient and the assumptions for the derivation of the rules are relatively well satisfied (perfectly for Rule I, a bit less so for Rule II). We can thus see that subjects prefer Rule II voting systems over Rule I voting systems when there is no payoff difference. Furthermore, although Rule I is given its best shot in *BI*, subjects do not even choose voting systems according to it significantly more often than voting systems not corresponding to any reasonable rule. When the results in treatments *BI* and *BA* are compared, we can see that subjects' choices are relatively

[23]Means (medians) of these comparisons are as follows. BI: 2.23(2), 3.11(3), 3.63(4); BA: 2.31(2), 3.56(4), 3.63(3.5); in the order 'R1-R2', 'R1-c', 'R2-c'.

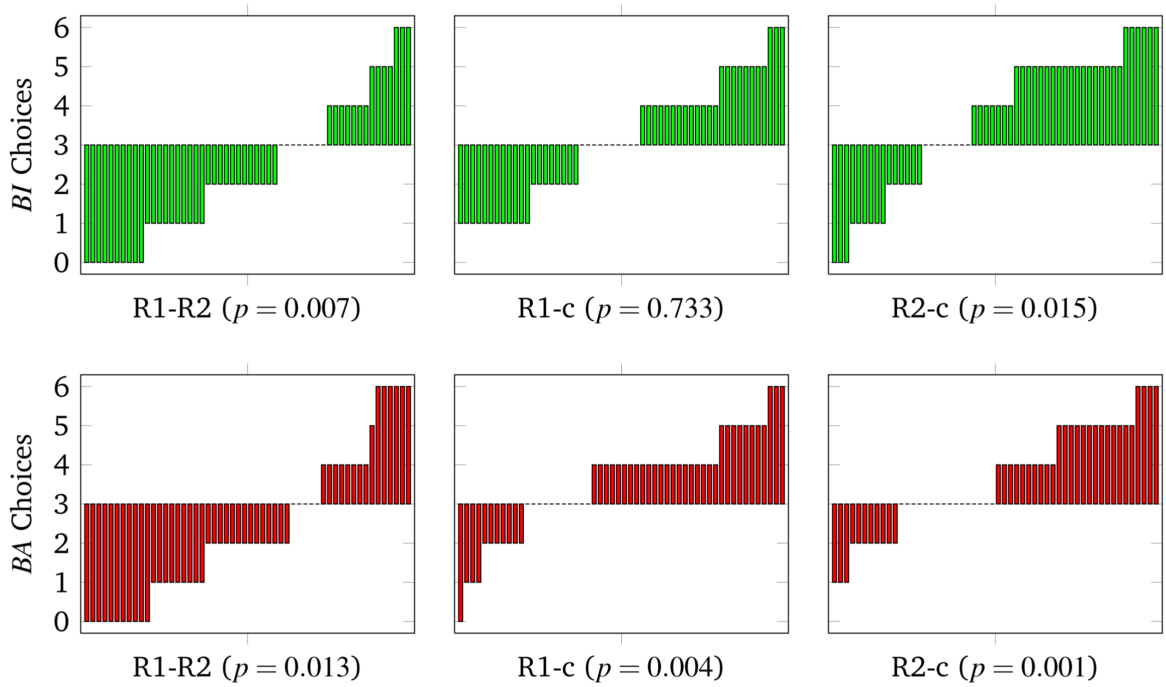

Figure 4: Participants' Choices

Notes: Each bar corresponds to a participant. The values are between 0 and 6. In the comparison, 'R1-R2' 0 means that a participant has chosen Rule I voting systems zero times in comparison with Rule II voting systems (and thus has chosen Rule II systems six times). The p-values stem from two-sided Wilcoxon signed rank tests.

robust to changes in the correlation structure of voting outcome preferences; although the outcomes might not be equal, the patterns have similar shapes. The results in treatment *BI* cannot be explained by expected utility maximization alone. The next section explores whether utility maximization is of any importance for participants' choices behind the veil in general.

4.2 Utility Maximization Plays a Role in Subjects' Choices

Result 1, as far as treatment *BI* is concerned, cannot be explained by expected utility maximization alone.[24] Next, I consider whether subjects in treatment *BA* choose the voting systems predicted by utility maximization (which are also predicted by other outcome based preferences, as explained in Section 2.3). Figure 5 shows a graph for each of the 18 choice situations in treatment *BA*. The first three choices are the choices

[24]Of course, because there are basically no differences in expected payoffs, any choice can be rationalized. However, utility maximization alone cannot explain systematic differences as observed in treatment *BI*.

of block 1, the next three of block 2, and so on. Within each block, the first choice bar corresponds to the proportion of Rule I systems chosen versus Rule II systems, the second one corresponds to Rule I systems versus the competitor, and the third choice bar corresponds to Rule II systems versus the competitor. The choice bars show how much more often one system has been chosen than the other one (for example, a value of -0.15 for a bar means that the first named voting system has been chosen 15 percentage points less often than the second named one). The payoff bars are scaled so that the sum of absolute values is equal to the sum of absolute values of the choice bars (i.e., the total surface of both types of bars is equal).

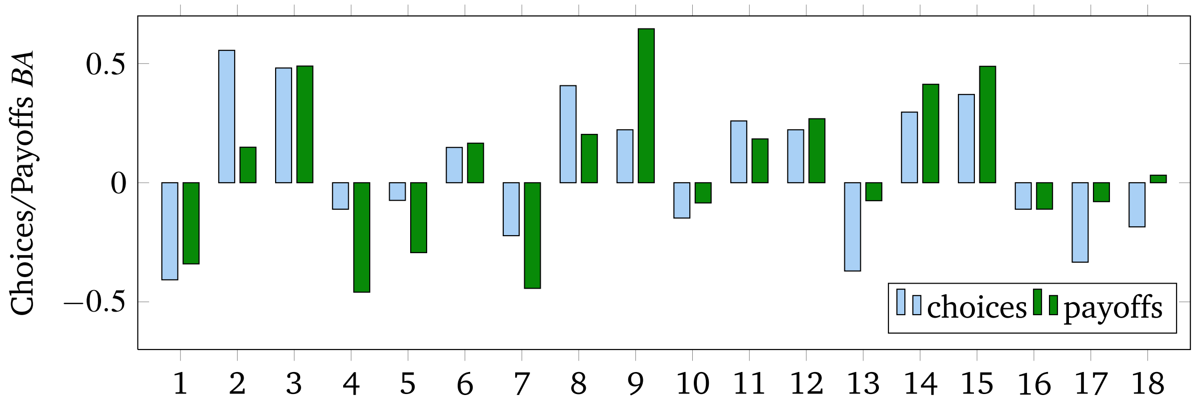

Figure 5: Differences in Choices and Expected Payoffs in Treatment *BA*

Notes: This graph shows differences in choices and expected payoffs for all 18 choice situations in *BA*. The first three choices are from block 1 and so on. Within each block, the first choice bar corresponds to 'R1-R2', the second corresponds to 'R1-c', and the third corresponds to 'R2-c'. The number on the y-axis represents how much more often one system has been chosen. The payoff bars represent the respective difference in expected payoffs, rescaled so that the total surface of both types of bars is equal.

Noise-free perfect utility maximization would thus mean that whenever a payoff bar is positive, the corresponding choice bar should be at plus one, and when a payoff bar is negative, the corresponding choice bar should be at negative one. This scenario is, of course, extreme and obviously not the case. More interesting is whether subjects consistently choose the more efficient system more often than the less efficient one (i.e., whether the choice bars are of the same sign as the corresponding payoff bars), which is indeed the case. The correlation between the differences in choices and the differences in expected payoffs is 0.756. A Pearson's product-moment correlation test yields a p-value of less than 10^{-3}, rejecting the null hypotheses of zero correlation.

There is thus a positive correlation between the voting systems that subjects choose in treatment *BA* and the expected payoffs of these voting systems. This correlation may stem from different reasons, however. For example, it could be the case that the most efficient voting systems usually coincide with Rule II voting systems. Indeed, Rule II voting systems are more efficient than Rule I voting systems (and Rule I tends to more efficient than the competitor). With a difference-in-differences analysis considering how the outcomes in *BI* and *BA* differ, one can correct for these general preferences (assuming that there is no reason why these general preferences for voting systems would be stronger in one of the treatments).

Now, I consider the correlation between the differences in choices between *BA* and *BI* and the differences in payoffs between *BA* and *BI*.[25] If this correlation is positive, it means that if people choose a voting system relatively more often in *BA* than in *BI*, on average, this goes together with an increase in expected payoff. Figure 6 shows the correlations of choices and expected payoffs in the difference-in-differences version.

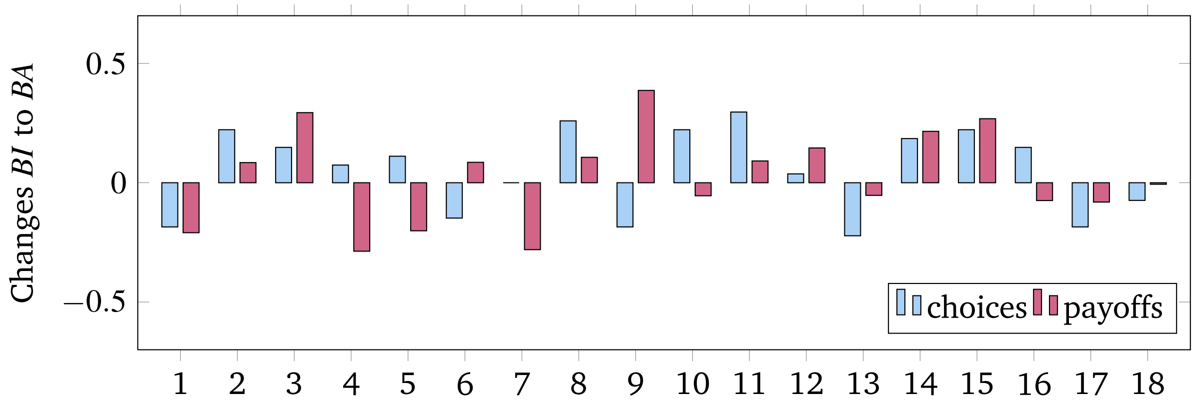

Figure 6: Difference in Differences *BI* to *BA*, Choices, and Expected Payoffs

Notes: The graph shows the difference in differences from treatment *BI* to *BA* in choices and expected payoffs in the 18 different choice situations (in the same order as for Figure 5). Expected payoff differences are scaled so that the total surface of payoff difference bars and choice difference bars is equal.

This correlation is indeed positive, but at 0.193, it is relatively low and statistically not significantly different from zero (the p-value of a Pearson's product-moment correlation test is 0.443). Taking the data without the observations of subjects who stated that they chose more or less randomly (see Footnote 22), the correlation increases to 0.661, and the difference from zero is statistically significant with a p-value of 0.003. Thus, there is evidence that subjects take payoff/utility considerations into account when making their choices in treatment *BA* where efficiency differences are present. This leads to the following result (keeping in mind that the predictions of utility maximizing behavior

[25] To be precise, for each decision situation – say, between voting systems *X* and *Y* – I consider the correlation between 'percentage point difference of voting system of type *X* chosen versus voting system of type *Y* in treatment *BA* minus percentage point difference of voting system of type *X* chosen versus voting system of type *Y* in treatment *BI*' and 'expected payoff of voting system *X* in *BA* minus expected payoff of voting system *Y* in *BA* minus [expected payoff of voting system *X* in *BI* minus expected payoff of voting system *Y* in *BI*]'. Of course, because payoff differences in *BI* are basically zero, the part in brackets is always very close to zero.

coincide with the predictions of basically all other outcome based preferences behind the veil of ignorance):

Result 2. *Maximizing expected utility can partially explain participants' choices.*

4.3 Subjects Choose Differently When They Are in Front of the Veil (to Their Own Group's Benefit)

Does it matter whether subjects know which group they will be in? Or are subjects in the laboratory so selfless (or confused) that they choose the same no matter which group they will be in? The answer is that in front of the veil of ignorance, subjects overwhelmingly choose in the interest of their own group. Note that here, voting power considerations and payoff considerations generally lead to the same outcome: the voting systems that are beneficial for one group have generally high voting power for this group (according to the Banzhaf index as well as the Shapley-Shubik index) and high expected payoffs.

Figure 7 shows the choices of participants in treatment *FA* who are either in the smallest or in the largest group. These choices are shown for all three comparisons in all six blocks. One can see that subjects in the small groups choose very differently from subjects in the large groups in each of the six blocks. Usually, when subjects in the smallest group favor one voting system over another, subjects in the largest group favor the other voting system. The voting systems that subjects of a group prefer are, in general, those that give more power and greater expected payoff to their group. For example, considering the fifth block, subjects in the smallest group in treatment *FA* prefer Rule I systems over Rule II systems and the competitor over both Rule I and Rule II systems. Indeed, this ordering is best for their group. The Banzhaf voting powers of this group for the three different voting systems are 0.176, 0.067, and 0.333 (in the following order: Rule I, Rule II, competitor); the Shapley-Shubik powers are 0.15, 0.05, and 0.383; and the probabilities of success are 0.594, 0.532, and 0.657, respectively. The largest group chooses the Rule I and Rule II voting systems much more often than the competitor. Indeed, voting power and expected payoffs are considerably higher for these systems for the large group. Differences between the Rule I and Rule II systems in this block are negligible for the large group; thus, it comes as no surprise that one system is only chosen slightly more often than the other. In general, this pattern holds roughly across all blocks and groups and similarly for treatment *BI*: subjects choose voting systems that are good for the group they are in according to both voting power and expected payoff. The respective data can be found in Appendix B.3.

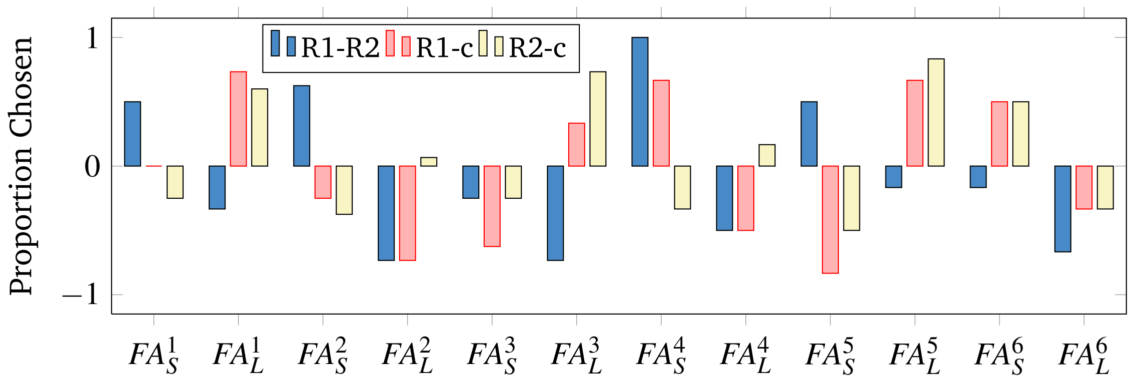

Figure 7: Choices in Front of the Veil for the Smallest and Largest Groups

Notes: The figure shows choices in treatment *FA*. The subscripts *S* and *L* denote the smallest and largest groups, respectively. The superscripts represent the decision block. The bars 'R1-R2' show how often voting systems according to Rule I have been chosen over voting systems according to Rule II (similar for 'R1-c' and 'R2-c').

Now, I test whether subject's choices are significantly different behind and in front of the veil of ignorance, where the data in front of the veil are split according to group membership. Therefore, I use the data on which system is chosen over both other systems in each decision block (the data can be found in Appendix B.3). With these data, one can test whether subjects choose differently using Fisher's exact test for $R \times C$ contingency tables. The null hypothesis of this test is that there is no difference in the proportions of choices between participants in different categories (treatments). For independent voting outcome preferences, the different categories for each decision block are BI, FI_A, FI_B, FI_C, FI_D and for blocks 4 to 6 also FI_E, similarly for aligned voting outcome preferences. Table 4 shows the p-values of these tests per block and for independent and aligned outcome preferences separately.

The results from these tests are overwhelmingly clear: in almost all blocks, the outcome that subjects choose differently is statistically highly significant. Nevertheless, what we actually want to know is whether there is a *systematic difference in at least one block*; this establishes that choices are different. Therefore, to be completely correct and to address potential problems of multiple testing, I also report Holm-Bonferroni corrected p-values in Table 4 (these p-values are naturally larger throughout; therefore, already one significant finding stands for a systematic difference). This leads us to the last result:

Result 3. *Participants' choices are different in front of the veil and behind the veil of ignorance (participants in front of the veil choose to the benefit of their own group).*

Table 4: Differences in Choices Behind and in Front of the Veil

	p-values		Holm-Bonferroni *p*-values	
Block	independent pref.	aligned pref.	independent pref.	aligned pref.
1	0.045	0.034	0.089	0.034
2	0.295	$< 10^{-3}$	0.295	0.003
3	$< 10^{-4}$	$< 10^{-5}$	$< 10^{-3}$	$< 10^{-4}$
4	$< 10^{-4}$	0.001	$< 10^{-3}$	0.003
5	$< 10^{-3}$	$< 10^{-3}$	$< 10^{-3}$	0.003
6	$< 10^{-4}$	$< 10^{-3}$	$< 10^{-3}$	0.002

Notes: This table shows the *p*-values of Fisher's exact test (null-hypothesis: proportions of preferred voting systems are equal). The categories for each decision block are *BI*, FI_A, FI_B, FI_C, FI_D and, where applicable, FI_E for independent preferences, similarly for aligned preferences.

5 Discussion

One important result of this paper is that people do not choose voting systems designed according to Penrose's Square Root Rule, even in treatment *BI*, which gives this rule its best shot. After theoretical criticisms of this rule have come up, based on the idea that success matters rather than decisiveness (see Laruelle and Valenciano, 2005), I show in this paper that participants behind the veil of ignorance do not choose voting systems designed according to this famous rule.

Voting systems designed according to the concept of proportional Shapley-Shubik power are chosen predominantly behind the veil of ignorance, even when efficiency concerns are absent. This general preference cannot be explained by outcome based concepts such as utility maximization, altruism, inequality aversion or social welfare maximization. A possible interpretation of this finding is that proportional Shapley-Shubik power corresponds to people's intuitive sense regarding which types of voting systems are good. When looking at the results from treatment *BA*, the findings can be interpreted as people starting from their intuitive feeling (predominantly choosing voting systems exhibiting proportional Shapley-Shubik power) and adjusting their choices in the direction that gives them a higher expected payoff. This interpretation is consistent with the choice pattern observed in treatment *BI*, and it is furthermore consistent with the facts that, on the one hand, participants' choices are relatively robust to changes in the correlation structure of outcome preferences and, on the other hand, payoffs can be shown to have an impact on participants' choices. The last result, showing that participants choose voting systems to their own benefit when they are in front of the veil, gives additional support to the other results. This result shows that it matters whether people are behind the veil of ignorance, and it shows that it is possible to meaningfully introduce a veil of ignorance in such an experiment.

One possible criticism of many laboratory experiments is that the student subject pool is not representative of the general population. Concerning this experiment, I consider it unlikely that the results depend on the composition of the subject pool. Subjects in front of the veil of ignorance primarily choose to their own benefit, whereas subjects behind the veil predominantly choose voting systems exhibiting proportional Shapley-Shubik power. This treatment difference might be slightly more or less pronounced in the general population, but it is very unlikely that it would be turned to its opposite (the same holds for the other results). Further discussion on the appropriateness of student subject pools can be found in Falk and Heckman (2009) and Falk and Fehr (2003).

What are the implications of this research for policy making? A policy maker or researcher who prefers Penrose's Square Root Rule on theoretical grounds might continue to do so if people in general do not choose or like voting systems according to this rule. However, this research suggests that the implementation of a voting system following Penrose's Square Root Rule is problematic because citizens (or, more generally, the people who will be subjected to the voting system) may not accept this voting system. In contrast, people may be much more willing to accept voting systems following the rule of proportional Shapley-Shubik power.

Of course, in the real world, people are usually in front of the veil of ignorance. Nevertheless, it appears reasonable to assume that the voting systems that will more easily be accepted by most people are the voting systems that are predominantly chosen behind the veil of ignorance. Acceptance of a voting system by the people who are subjected to it is of utmost importance in most situations involving voting. The EU is one example of this; politicians in Brussels are continuously worried about the acceptance of EU institutions by their citizens. This research is thus relevant not only for researchers but also for people designing voting systems, whether they do this for a multinational institution or for one of the many small associations making use of two-tier voting.

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A Appendix (for Online Publication): Instructions, Test Questions, and Questionnaire

Here, the instructions and test questions of the experiment can be found. Because a considerable amount of graphical illustration has been used, it seems to be the most comprehensible for the reader to see the screenshots. The first set of instructions corresponds to the treatment *BI*. The differences in the instructions to the other treatments concern only a few screens. After the full set of instructions for *BI*, the screens that are different for the other treatments will be shown. Note that on top of the different screens, also the answers to the test questions can be different, depending on the treatment (the screens of the test questions are the same, they have thus not been reproduced multiple times).

The questionnaire in the end asks for the following attributes and the following questions. Answer possibilities where present are in parentheses. 1) Gender (Male/Female). 2) Age. 3) Have you participated in a CREED experiment before? (No / Yes, once or twice / Yes, more than twice). 4) Nationality. 5) How clear were the instructions of the experiment (Clear / Not as clear as possible, but understandable / Unclear). 6) Which of the following comes closest to your field of study [multiple answer possibilities, not reproduced here]. 7) Which of the following describes your decisions in the first part of the experiment best? (I have tried to make the decisions in a way that I thought was sensible. / I have made my decisions more or less randomly, because I didn't really understand the task and/or its consequences. / I have made my decisions more or less randomly for other reasons (if so, please specify below).). 8) If you had a certain way of making decisions in the first part of the experiment, can you describe it very briefly? 9) Which of the following describes your decisions in the second part of the experiment best? (I have tried to make the decisions in a way that I thought was sensible. / I have made my decisions more or less randomly, because I didn't really understand the task and/or its consequences. / I have made my decisions more or less randomly for other reasons (if so, please specify below).). 10) If you had a certain way of making decisions in the second part of the experiment, can you describe it very briefly? 11) How would you describe your command of English? (Excellent / Very good / Good / Fair / Bad) 12) Are there any comments you would like to leave for us?

A.1 Screenshots of Instructions and Test Questions, Treatment *BI*

Figures 8 to 19 contain screenshots of the instructions and test questions for treatment *BI*. They appear in the same order as in the experiment.

Introduction	Instructions I	Instructions II	Instructions III	Instructions IV	Questions I	Questions II	Continue

Welcome to this experiment!

This experiment is anonymous; the data from your choices will only be linked to your station id, not to your name. You will be paid privately at the end, after all participants have finished the experiment. The experiment will take approximately 2 hours. You will spend a considerable fraction of this time reading instructions.

This experiment consists of two parts. You will receive instructions for the second part before it begins. **Please read all instructions VERY carefully**, otherwise you might be lost later on in the experiment. There will be test questions before you can continue to the experiment. You can use the menu on top of the screen to go back to previous parts of the instructions.

Payments during the experiment are in points. 80 points will be exchanged into 1 Euro. For showing up and answering all questions carefully you receive a fixed payment of 12 euros. Everything you earn during the experiment will come on top of this.

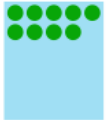
You are not allowed to speak with other participants or to communicate with them in any other way. **If you want to ask a question at any time, please raise your hand and someone will come to your desk.**

Next

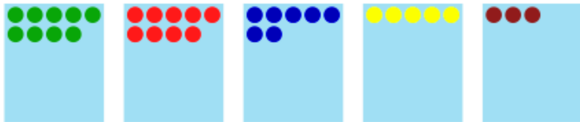
Figure 8

Introduction | **Instructions I** | Instructions II | Instructions III | Instructions IV | Questions I | Questions II | Continue

In the experiment there will be different groups. The groups can have different sizes. A group is represented by a small rectangle with circles in it, each circle stands for one group member. A group of 9 individuals would thus look as shown below (colors have no meaning other than to distinguish different groups).



In the experiment there will always be either 4 or 5 groups. If there are 5 different groups, they could look as shown below (remember, each circle stands for one group member). If there are only four groups, there will be no brown group.



The colors from left to right are always: green, red, blue, yellow, sometimes brown.

Together, the groups have to vote. There are two possible 'outcomes', called X and Y. Each group has exactly one vote. It can either vote for X or for Y, abstention (i.e. not voting) is not possible. (Note that it is the groups that vote and not the individuals in the groups.)

The final outcome is the result of how each group votes and of the voting system used. Your decisions in today's experiment will determine the voting system. You will thus have to understand very well what such a voting system is and how it works.

Next

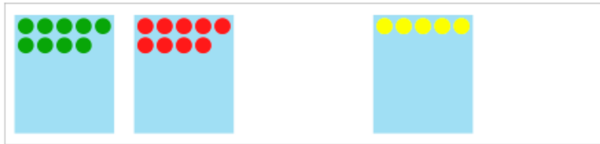
Figure 9

Introduction | Instructions I | **Instructions II** | Instructions III | Instructions IV | Questions I | Questions II | Continue

Assume that there are the following five groups (the same as shown before).

As mentioned, the groups can vote for either X or Y. There are different combinations of group votes possible, one would for example be: the green, the red, and the yellow groups vote for X, the blue and the brown groups vote for Y. We will illustrate a combination of votes by only showing the groups that vote for X. All other groups then vote for Y.

Thus, our example (green, red, yellow groups vote for X – blue, brown groups vote for Y) would look as shown below. The green, the red, and the yellow groups are shown (the X-votes) and the places where the groups would be located that vote for Y are left empty (the spots for the blue and the brown groups).



Next

Figure 10

Introduction | Instructions I | Instructions II | **Instructions III** | Instructions IV | Questions I | Questions II | Continue

A voting system decides for all possible combinations of (group) votes whether the outcome will be X or Y. Thus, you can think of a voting system as a list that contains all possible combinations in which the groups can vote and for each of these combinations it says whether the outcome is X or Y. Instead of giving this whole list it is sufficient to give a list of all combinations of group votes that lead to outcome X. All the combinations that are not in the list then automatically lead to outcome Y.

All in all, we will describe a voting system by providing all combinations of X-voting groups that yield outcome X. For example, if you see a row showing a green and a red group and empty spots where other groups would be, this means that the situation "the green and the red groups vote for X while the other groups vote for Y" leads to outcome X.

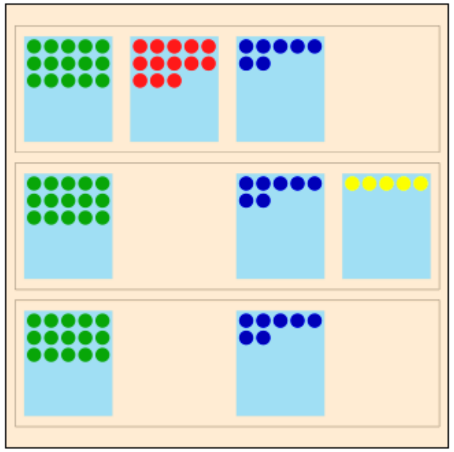
We illustrate this as follows. **A voting system is a large rectangle with multiple rows. Each row shows a combination of group votes that leads to the outcome X (remember, within one row, groups that are shown are X-votes, groups that are left out are Y-votes). If a combination of votes is not shown as a row in the large rectangle, this combination does not lead to the outcome X and thus it leads to the outcome Y.** There is one exception, however. If all groups vote for X the outcome will always be X – as this is self-evident the row representing all groups voting for X is never shown in the rectangle.

To summarize: For any voting system, if you want to know for a certain combination of votes whether the outcome will be X or Y, you check all rows of the voting system and check whether there is a row representing this combination. If you find such a row the outcome will be X, if you do not find such a row the outcome will be Y.

Take a look at the very simple voting system on the right. There are four groups (there is no brown group).

The first row says that if the green, red, and blue groups vote for X and the yellow group votes for Y, the outcome is X. The second row says that X-votes of green, blue, and yellow lead to the outcome X. And the third one says that the X-votes of green and blue alone lead to outcome X.

Except for the case that all groups vote for X, these combinations of votes are the only ones that lead to outcome X. Thus, for example the situation "red, blue, and yellow vote for X, green votes for Y" leads to outcome Y (there is no row showing only the red, blue, and yellow group). Similarly, if only the green and the yellow groups vote for X, the outcome will be Y.



Next

Figure 11

Introduction | Instructions I | Instructions II | Instructions III | **Instructions IV** | Questions I | Questions II | Continue

Additional information: All voting systems that you will see in this experiment have the following property. If a combination of groups voting for X leads to the outcome X, then the outcome will also be X if another group votes for X in addition. This means for example that if you, as below, see a row showing only the green, the red, and the brown group (fifth row), you can be sure that there will also be a row showing the green, the red, the brown, and the blue group (second row) and a row showing the green, the red, the brown, and the yellow group (third row).

Let's look at more examples with the voting system shown on this page.

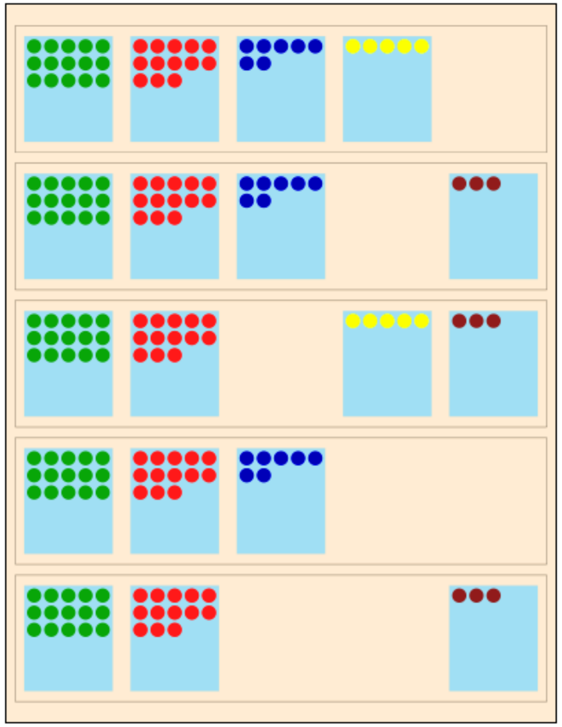
If the green, red, and blue groups vote for X and the yellow and brown groups vote for Y, what will be the outcome? The answer is X, because the fourth row represents this combination of votes (green, red, and blue are shown, i.e. vote for X, yellow and brown are left out, i.e. vote for Y; this row is in the large rectangle, thus the outcome will be X).

If instead the red, blue, yellow, and brown groups vote for X and the green group votes for Y, what will be the outcome? The answer is Y, because this combination is not represented in the rectangle (there is no row without the green and with the red, blue, yellow, and brown groups).

How about if all groups vote for X? The outcome will be X even though there is no row with all groups – as mentioned above this row is always left out, because self-evidently all groups agreeing on X leads to the outcome X.

What if all groups with at least 6 members vote for X and the others vote for Y? The brown and the yellow groups have fewer than 6 members (3 and 5) and thus vote for Y. The green (15), the red (13), and the blue (7) groups have more than 6 members and thus vote for X. This means that the outcome will be X (fourth row).

How about if the green, red, and yellow groups vote for X, the others for Y? The outcome will be Y as there is no row showing just the green, red, and yellow groups. Does this change if instead of the yellow 5-person group the brown 3-person group votes for X? The answer is yes, then the outcome will be X, because the fifth row shows the green, the red, and the brown groups. You can thus see that if you replace an X-vote of a larger group with an X-vote of a smaller group it might sometimes change the outcome from Y to X – it depends on the voting system.



Next

Figure 12

Introduction | Instructions I | Instructions II | Instructions III | Instructions IV | **Questions I** | Questions II | Continue

All questions refer to the voting system illustrated on the right.

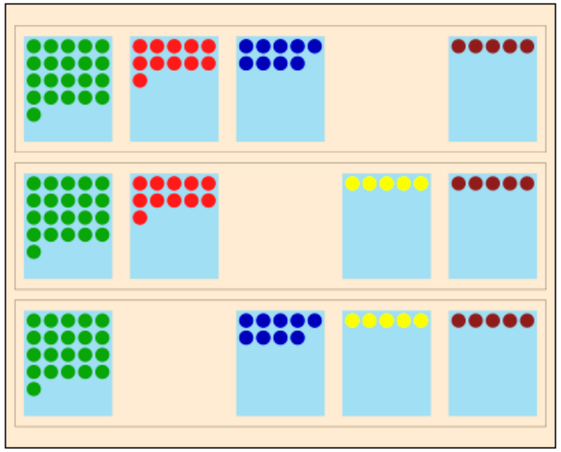
If the brown group votes for Y, can the outcome ever be X?
- ◯ Yes, it depends on the votes of the other groups.
- ◯ No.

If the brown group votes for X, can the outcome ever be Y?
- ◯ Yes, it depends on the votes of the other groups.
- ◯ No.

If three groups vote for X and two groups for Y, what will be the outcome?
- ◯ X
- ◯ Y
- ◯ That depends which groups vote for X and which for Y.

If the red group votes for X, what will be the outcome?
- ◯ X
- ◯ Y
- ◯ That depends on the votes of the other groups.

If all groups vote for X, what will be the outcome?
- ◯ X, it does not matter that there is no row showing all groups.
- ◯ Y, because there is no row showing all groups.



Send

Figure 13

Introduction | Instructions I | Instructions II | Instructions III | Instructions IV | Questions I | **Questions II** | Continue

All questions refer to the voting system illustrated on the right. (Now there are only 4 different groups, green, red, blue, and yellow.)

If the green, the red, the blue, and the yellow group vote for X, what will be the outcome?

- ◯X
- ◯Y

If the group with 13 members and the group with 7 members vote for X, will the outcome always be X?

- ◯Yes.
- ◯No, it depends on the votes of the other groups.

If the green and the red group vote for Y, will the outcome always be Y?

- ◯Yes.
- ◯No, it depends on the votes of the other groups.

If the green and the yellow group vote for Y, will the outcome always be Y?

- ◯Yes.
- ◯No, it depends on the votes of the other groups.

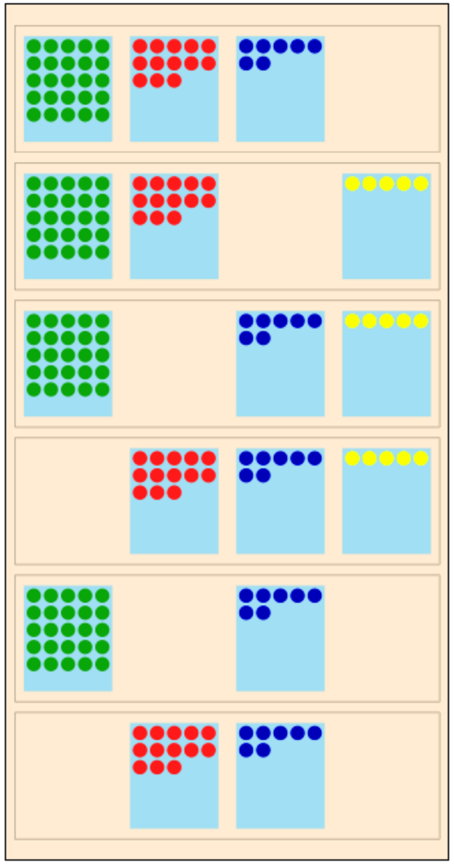


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Figure 14

Introduction | Instructions I | Instructions II | Instructions III | Instructions IV | Questions I | Questions II | **Continue**

By now you should have understood very well what a voting system is and how it is illustrated. There will be some more instructions, explaining what you have to do in part 1. Note that you cannot go back to the explanation of the voting system after you click *Continue*.

If anything is unclear raise your hand and someone will come to your desk.

Continue

Figure 15

Instructions I | Instruction II | Questions | Summary

The groups vote to choose between the two possible outcomes X and Y. You know now how the outcome is determined given the votes of the groups and given a voting system (the voting system used will depend on your choices). What the groups vote for depends on the preferences of the group members, which are the participants of the experiment.

Each participant either prefers X or Y. Whether you prefer X or Y will not be determined until the end of the experiment. The probability that you prefer X (or Y, similarly) is one half. This probability is the same for all participants independently of the group they are in and independently of the random preferences of other participants.

If the majority of members of a group prefers X the group will vote for X, if the majority of members prefers Y the group will vote for Y (all groups have an odd number of members, ties are thus not possible). This is done automatically, you cannot change the way your group votes.

The outcome (X or Y, determined by the group voting) will determine your earnings. Your earnings are 1000 points if your preference is equal to the outcome. If not, your earnings are 0.

Next

Figure 16

Instructions I | **Instruction II** | Questions | Summary

During part 1, you will be asked to make 18 decisions. Each decision consists of choosing one out of two voting systems. You will see a screen with one voting system on the left and one on the right. You choose one of these voting systems by clicking on it. In the end of the experiment, one of the 18 chosen voting systems from one participant of the experiment will be selected randomly to determine the payments.

Just before determining participants' preferences, outcome, and earnings (in this order), all participants of the experiment will be randomly distributed over the groups, so that each group has exactly the number of members for the selected situation. In some situations, the number of participants is larger than the sum of members of the various groups. In this case, some participants will be unlucky – they will not be part of any group and also not receive any payment for part 1 (if one of your choices is implemented you will always be in one of the groups). **It is important to note that when making your decisions you do not yet know which group you will be in later when the payments are determined.**

The 18 decision situations are split in 6 blocks. Groups differ from block to block (3 blocks with 4 groups and 3 blocks with 4 groups). The complexity of the voting systems varies, the "largest" one consist of 7 rows with 5 groups, the "smallest" one of 3 rows with 4 groups.

Next

Figure 17

Instructions I | Instruction II | **Questions** | Summary

It is randomly determined whether you prefer X or Y. How is this determined?

- ◯ The probability of you prefering either option is one half, independently of all other outcomes.
- ◯ Everyone in the same group as you will have the same preference as you. The probability of X being the preference of everyone in the group is one half.
- ◯ All participants of this experiment will have the same preference as you. The probability of Y being this preference is one half.

To determine the outcome the groups will vote. This is done after participants have been distributed over the groups. How is it determined whether a group votes for X or for Y?

- ◯ Some group members can prefer X while some others prefer Y. If more members of the group prefer X the group votes for X, if more members prefer Y the group votes for Y.
- ◯ All members of one group always prefer the same. If the members prefer X the group votes for X, if the members prefer Y the group votes for Y.
- ◯ There will be a seperate voting stage in which all members determine the group vote, which can be voting for X, for Y, or abstaining.

For showing up and answering all questions carefully you will receive a payment of 12 euros. The earnings from part 1 and 2 of the experiment come on top of this. What about the earnings from part 1 of the experiment?

- ◯ You can earn any number of points between 0 and 1800, depending on luck and the different choices you make.
- ◯ You will earn 1000 points from part 1 if the outcome is the same as your preference, nothing otherwise.

Send

Figure 18

Instructions I | Instruction II | Questions | **Summary**

There are 18 different decision situations with two voting systems each. You are asked to always choose the one that you prefer. Afterwards, one situation and one participant are selected and participants are randomly allocated to groups for the selected situation. Next, it is randomly determined for each participant whether he/she prefers X or Y. If the majority in a group prefers X, the group votes for X. If the majority prefers Y, the group votes for Y. Then, the voting system chosen by the selected individual is implemented, which determines whether the outcome is X or Y.

If the outcome is the same as your preference you earn 1000 points, otherwise you earn nothing.

If anything is unclear raise your hand and someone will come to your desk.

Start experiment

Figure 19

A.2 Instruction Differences in the In Front of the Veil Treatments

Figure 20 shows a screenshot of the part of the instructions where the treatments *FI* and *FA*, i.e. the in front of the veil treatments, both differ from the instructions of treatment *BI*.

Instructions I | **Instruction II** | Questions | Summary

During part 1, you will be asked to make 18 decisions. Each decision consists of choosing one out of two voting systems. You will see a screen with one voting system on the left and one on the right. You choose one of these voting systems by clicking on it. You will see an arrow above each voting system that indicates which group you will be in for payment if your choice is implemented. In the end of the experiment, one of the 18 chosen voting systems from one participant of the experiment will be selected randomly to determine the payments.

Just before determining participants' preferences, outcome, and earnings (in this order), all participants of the experiment will be randomly distributed over the groups, so that each group has exactly the number of members for the selected situation. In some situations, the number of participants is larger than the sum of members of the various groups. In this case, some participants will be unlucky – they will not be part of any group and also not receive any payment for part 1 . If one of your choices is implemented you will be in the group that was indicated in the respective choice situation by an arrow.

The 18 decision situations are split in 6 blocks. Groups differ from block to block (3 blocks with 4 groups and 3 blocks with 4 groups). The complexity of the voting systems varies, the "largest" one consist of 7 rows with 5 groups, the "smallest" one of 3 rows with 4 groups.

Next

Figure 20

A.3 Instruction Differences in the Group Aligned Preference Treatments

Figures 21 and 22 show screenshots of the part of the instructions where the treatments *BA* and *FA*, i.e. the group aligned treatments, both differ from the instructions of treatment *BI*. Note that also the answers to the test questions are partly different, while the questions themselves are not different.

Instructions I | Instruction II | Questions | Summary

The groups vote to choose between the two possible outcomes X and Y. You know now how the outcome is determined given the votes of the groups and given a voting system (the voting system used will depend on your choices). What the groups vote for depends on the preferences of the group members, which are the participants of the experiment.

Each participant either prefers X or Y. Whether you prefer X or Y will not be determined until the end of the experiment. In each group either all members prefer X or all members prefer Y. The probability that the members of a group prefer X (or Y, similarly) is one half. This probability is the same for all groups independently of the random preferences of participants in other groups.

If the members of a group prefer X the group will vote for X, if the members prefer Y the group will vote for Y. This is done automatically, you cannot change the way your group votes.

The outcome (X or Y, determined by the group voting) will determine your earnings. Your earnings are 1000 points if your preference is equal to the outcome. If not, your earnings are 0.

Next

Figure 21

Instructions I | Instruction II | Questions | **Summary**

There are 18 different decision situations with two voting systems each. You are asked to always choose the one that you prefer. Afterwards, one situation and one participant are selected and participants are randomly allocated to groups for the selected situation. Next, it is randomly determined for each group whether its members prefer X or Y. If they prefer X, the group votes for X. If they prefer Y, the group votes for Y. Then, the voting system chosen by the selected individual is implemented, which determines whether the outcome is X or Y.

If the outcome is the same as your preference you earn 1000 points, otherwise you earn nothing.

If anything is unclear raise your hand and someone will come to your desk.

Start experiment

Figure 22

B Appendix (for Online Publication): Properties of the Decision Blocks, Additional Information on the Selection Procedure, and Additional Graphs and Data

B.1 Properties of the Decision Blocks

Tables 5 to 10 contain the properties of the decision blocks. Other than the groups and their sizes and the sets of winning coalitions according to each rule (including the competitor), the tables also show the optimal distribution of the Banhaf index (PB) or the Shapley-Shubik (SS) index, according to the theoretical Rules I and II, respectively. Furthermore the actual Banzhaf and Shapley-Shubik indices of all the three sets of winning coalitions used are shown. Then the probabilities of being successful as any member (behind the veil treatments) or as a member of a certain group (in front of the veil treatments, ordered from smallest to largest group) for each of the three voting systems are shown, first for independent voting outcome preferences (treatments *BI* and *FI*), then for group aligned voting outcome preferences (treatments *BA* and *FA*). These probabilities have been simulated with two million runs of the voting situation for each of the values attained. Furthermore, the tables show for each of the three voting systems the error terms that arise with respect to the optimal solution for the classical Method 1 from Section 2 and the coefficient of variation used for Method 2. This is done using the Banzhaf index when calculating these errors (or the coefficients of variation) according to the theoretical Rule I and using the Shapley-Shubik index when using the methods according to the theoretical Rule II.

Table 5: Properties, Decision Block 1

Constellation of Groups	D:3 C:3 B:15 A:19
Optimal PB index Rule 1	0.1411873 0.1411873 0.3370064 0.3806190
Optimal SS index Rule 2	0.075 0.075 0.375 0.475
Concept Rule 1	{D, C, A}, {D, B, A}, {C, B, A}
Concept Rule 2	{B, A}, {D, B, A}, {C, B, A}
Concept Competitor (c)	{D, C, B}, {D, B, A}, {C, B, A}
Normalized PB index R1	0.2 0.2 0.2 0.4
Normalized PB index R2	0.0 0.0 0.5 0.5
Normalized PB index c	0.2 0.2 0.4 0.2
SS index R1	0.1666667 0.1666667 0.1666667 0.5000000
SS index R2	0.0 0.0 0.5 0.5
SS index c	0.1666667 0.1666667 0.5000000 0.1666667
Success prob, indep pref, behind veil, R1/R2/c	0.5412222 / 0.5416947 / 0.5400489
Success prob, indep pref, per group R1	0.5623765 / 0.562324 / 0.526179 / 0.5464264
Success prob, indep pref, per group R2	0.4997673 / 0.4999598 / 0.5523717 / 0.5464754
Success prob, indep pref, per group c	0.5624157 / 0.5624712 / 0.5523567 / 0.5232603
Success prob, aligned pref, behind veil, R1/R2/c	0.6843514 / 0.7127205 / 0.6719335
Success prob, aligned pref, per group R1	0.6250865 / 0.625031 / 0.625184 / 0.7497865
Success prob, aligned pref, per group R2	0.5002325 / 0.500177 / 0.750038 / 0.7503695
Success prob, aligned pref, per group c	0.625271 / 0.6252155 / 0.7496395 / 0.625331
Error term according R1 (method 1, PB) R1/R2/c	0.08795622 / 0.140436 / 0.1322987
Error term according R2 (method 1, SS) R1/R2/c	0.1335415 / 0.083666 / 0.2286433
Coeff var according R1 (method 2, PB) R1/R2/c	0.3119119 / 0.4252265 / 0.4087207
Coeff var according R2 (method 2, SS) R1/R2/c	0.5840639 / 0.4392977 / 0.6825591

Notes: 'Optimal PB index Rule 1' is the theoretically optimal PB index according to Rule 1, similarly for 'Optimal SS index Rule 2'. The concepts according to Rule 1 and 2 are the sets of winning coalitions performing best in terms of these rules, 'Concept Competitor' is the competing voting system (not performing well according to the two rules). The normalized PB indices and the SS indices are shown for all three voting systems. Also shown is the probability of success of an individual, behind or in front of the veil of ignorance (in front split up according to groups, ordered from smallest group (here D, can also be E) to largest group (A)). The error terms are the error terms of the concepts according to the theoretical rules when using the classic Method 1 as in Section 2. The coefficient of variation used for Method 2.

Table 6: Properties, Decision Block 2

Constellation of Groups	D:3 C:5 B:7 A:21
Optimal PB index Rule 1	0.1476872 0.1969163 0.2362996 0.4190968
Optimal SS index Rule 2	0.08333333 0.13888889 0.19444444 0.58333333
Concept Rule 1	{B, A}, {D, C, B}, {D, C, A}, {D, B, A}, {C, B, A}
Concept Rule 2	{C, A}, {B, A}, {D, C, A}, {D, B, A}, {C, B, A}
Concept Competitor (c)	{D, A}, {C, A}, {D, C, A}, {D, B, A}, {C, B, A}
Normalized PB index R1	0.1666667 0.1666667 0.3333333 0.3333333
Normalized PB index R2	0.0 0.2 0.2 0.6
Normalized PB index c	0.2 0.2 0.0 0.6
SS index R1	0.1666667 0.1666667 0.3333333 0.3333333
SS index R2	0.0000000 0.1666667 0.1666667 0.6666667
SS index c	0.1666667 0.1666667 0.0000000 0.6666667
Success prob, indep pref, behind veil, R1/R2/c	0.5526175 / 0.5526517 / 0.5502265
Success prob, indep pref, per group R1	0.5622135 / 0.5469948 / 0.5780369 / 0.5441122
Success prob, indep pref, per group R2	0.4999022 / 0.5469484 / 0.5390204 / 0.566089
Success prob, indep pref, per group comp	0.5623315 / 0.5470398 / 0.5000138 / 0.5659935
Success prob, aligned pref, behind veil, R1/R2/c	0.7221737 / 0.7604319 / 0.7466079
Success prob, aligned pref, per group R1	0.6249915 / 0.625061 / 0.7501065 / 0.749868
Success prob, aligned pref, per group R2	0.499844 / 0.6251955 / 0.624959 / 0.8750155
Success prob, aligned pref, per group comp	0.624664 / 0.6250945 / 0.500139 / 0.8751165
Error term according R1 (method 1, PB) R1/R2/c	0.07923726 / 0.145483 / 0.1737147
Error term according R2 (method 1, SS) R1/R2/c	0.2022253 / 0.06990587 / 0.1099476
Coeff var according R1 (method 2, PB) R1/R2/c	0.2564921 / 0.3686197 / 0.5076884
Coeff var according R2 (method 2, SS) R1/R2/c	0.5433582 / 0.3236694 / 0.5433582

Table 7: Properties, Decision Block 3

Constellation of Groups	D:3 C:5 B:9 A:27
Optimal PB index Rule 1	0.1353527 0.1804702 0.2475020 0.4366750
Optimal SS index Rule 2	0.06818182 0.11363636 0.20454545 0.61363636
Concept Rule 1	{C, A}, {B, A}, {D, C, B}, {D, C, A}, {D, B, A}, {C, B, A}
Concept Rule 2	{D, A}, {C, A}, {B, A}, {D, C, A}, {D, B, A}, {C, B, A}
Concept Competitor (c)	{D, A}, {C, A}, {D, C, B}, {D, C, A}, {D, B, A}, {C, B, A}
Normalized PB index R1	0.08333333 0.25000000 0.25000000 0.41666667
Normalized PB index R2	0.1 0.1 0.1 0.7
Normalized PB index c	0.25000000 0.25000000 0.08333333 0.41666667
SS index R1	0.08333333 0.25000000 0.25000000 0.41666667
SS index R2	0.08333333 0.08333333 0.08333333 0.75000000
SS index c	0.25000000 0.25000000 0.08333333 0.41666667
Success prob, indep pref, behind veil, R1/R2/c	0.5503359 / 0.549906 / 0.5476233
Success prob, indep pref, per group R1	0.5314262 / 0.5704411 / 0.5513113 / 0.5483886
Success prob, indep pref, per group R2	0.5313193 / 0.5235484 / 0.5172294 / 0.5677444
Success prob, indep pref, per group comp	0.593859 / 0.5706518 / 0.5171714 / 0.5483721
Success prob, aligned pref, behind veil, R1/R2/c	0.7558185 / 0.792744 / 0.738921
Success prob, aligned pref, per group R1	0.562579 / 0.687716 / 0.6871145 / 0.8128025
Success prob, aligned pref, per group R2	0.5624065 / 0.5626975 / 0.562096 / 0.937821
Success prob, aligned pref, per group comp	0.6872255 / 0.6875165 / 0.562468 / 0.813002
Error term according R1 (method 1, PB) R1/R2/c	0.03131772 / 0.2186799 / 0.08487629
Error term according R2 (method 1, SS) R1/R2/c	0.1623534 / 0.1205647 / 0.1765774
Coeff var according R1 (method 2, PB) R1/R2/c	0.1692904 / 0.457098 / 0.4173818
Coeff var according R2 (method 2, SS) R1/R2/c	0.4902338 / 0.3370167 / 0.8851774

Table 8: Properties, Decision Block 4

Constellation of Groups	E:1 D:5 C:11 B:13 A:15
Optimal PB index Rule 1	0.0590425 0.1574467 0.2399187 0.2617295 0.2818626
Optimal SS index Rule 2	0.02222222 0.11111111 0.24444444 0.28888889 0.33333333
Concept Rule 1	{E, D, B, A}, {E, C, B, A}, {D, C, B, A}
Concept Rule 2	{C, B, A}, {E, C, B, A}, {D, C, B, A}
Concept Competitor (c)	{D, C, A}, {E, D, C, A}, {D, C, B, A}
Normalized PB index R1	0.1428571 0.1428571 0.1428571 0.2857143 0.2857143
Normalized PB index R2	0.0000000 0.0000000 0.3333333 0.3333333 0.3333333
Normalized PB index c	0.0000000 0.3333333 0.3333333 0.0000000 0.3333333
SS index R1	0.10 0.10 0.10 0.35 0.35
SS index R2	0.0000000 0.0000000 0.3333333 0.3333333 0.3333333
SS index c	0.0000000 0.3333333 0.3333333 0.0000000 0.3333333
Success prob, indep pref, behind veil, R1/R2/c	0.5246491 / 0.524443 / 0.5214918
Success prob, indep pref, per group R1	0.5621735 / 0.523247 / 0.5153432 / 0.5283421 / 0.5262385
Success prob, indep pref, per group R2	0.499726 / 0.4997985 / 0.5307395 / 0.5284168 / 0.5262444
Success prob, indep pref, per group comp	0.500018 / 0.5466679 / 0.5307172 / 0.5002553 / 0.5261711
Success prob, aligned pref, behind veil, R1/R2/c	0.6012695 / 0.608331 / 0.5859561
Success prob, aligned pref, per group R1	0.562155 / 0.5623885 / 0.562017 / 0.62517 / 0.624909
Success prob, aligned pref, per group R2	0.4995395 / 0.499773 / 0.6246325 / 0.6253375 / 0.6250765
Success prob, aligned pref, per group comp	0.499832 / 0.6250465 / 0.624441 / 0.500064 / 0.624885
Error term according R1 (method 1, PB) R1/R2/c	0.05151498 / 0.08561067 / 0.1622361
Error term according R2 (method 1, SS) R1/R2/c	0.08012336 / 0.06232795 / 0.1775925
Coeff var according R1 (method 2, PB) R1/R2/c	0.3077011 / 0.3985151 / 0.7274828
Coeff var according R2 (method 2, SS) R1/R2/c	0.6102848 / 0.4153242 / 0.8876254

Table 9: Properties, Decision Block 5

Constellation of Groups	E:5 D:5 C:7 B:15 A:17
Optimal PB index Rule 1	0.1449324 0.1449324 0.1739189 0.2594595 0.2767568
Optimal SS index Rule 2	0.1020408 0.1020408 0.1428571 0.3061224 0.3469388
Concept Rule 1	{E, D, C, A}, {E, D, B, A}, {E, C, B, A}, {D, C, B, A}
Concept Rule 2	{C, B, A}, {E, D, B, A}, {E, C, B, A}, {D, C, B, A}
Concept Competitor (c)	{E, C, B}, {E, D, C, B}, {E, D, C, A}, {E, C, B, A}
Normalized PB index R1	0.1764706 0.1764706 0.1764706 0.1764706 0.2941176
Normalized PB index R2	0.06666667 0.06666667 0.20000000 0.33333333 0.33333333
Normalized PB index c	0.33333333 0.06666667 0.33333333 0.20000000 0.06666667
SS index R1	0.15 0.15 0.15 0.15 0.40
SS index R2	0.0500000 0.0500000 0.1333333 0.3833333 0.3833333
SS index c	0.3833333 0.0500000 0.3833333 0.1333333 0.0500000
Success prob, indep pref, behind veil, R1/R2/c	0.5279604 / 0.5271842 / 0.522236
Success prob, indep pref, per group R1	0.5350678 / 0.5353033 / 0.5291155 / 0.5195876 / 0.5306224
Success prob, indep pref, per group R2	0.5117695 / 0.5119502 / 0.5290851 / 0.5326312 / 0.5306096
Success prob, indep pref, per group comp	0.558684 / 0.5117015 / 0.5486878 / 0.5196336 / 0.5060187
Success prob, aligned pref, behind veil, R1/R2/c	0.6155086 / 0.6217915 / 0.581092
Success prob, aligned pref, per group R1	0.594195 / 0.5942325 / 0.5928295 / 0.5936005 / 0.656704
Success prob, aligned pref, per group R2	0.531504 / 0.5315415 / 0.5925965 / 0.6562915 / 0.656471
Success prob, aligned pref, per group comp	0.6567345 / 0.531697 / 0.655349 / 0.593661 / 0.5317055
Error term according R1 (method 1, PB) R1/R2/c	0.04916097 / 0.06425278 / 0.1557973
Error term according R2 (method 1, SS) R1/R2/c	0.09441924 / 0.05338688 / 0.2373642
Coeff var according R1 (method 2, PB) R1/R2/c	0.2099367 / 0.2916223 / 0.8261977
Coeff var according R2 (method 2, SS) R1/R2/c	0.3649335 / 0.2775044 / 1.248378

Table 10: Properties, Decision Block 6

Constellation of Groups	E:3 D:5 C:7 B:13 A:19
Optimal PB index Rule 1	0.1130502 0.1507336 0.1808803 0.2505701 0.3047658
Optimal SS index Rule 2	0.06382979 0.10638298 0.14893617 0.27659574 0.40425532
Concept Rule 1	{D, B, A}, {C, B, A}, {E, D, C, B}, {E, D, C, A}, {E, D, B, A}, {E, C, B, A}, {D, C, B, A}
Concept Rule 2	{E, B, A}, {D, B, A}, {C, B, A}, {E, D, C, A}, {E, D, B, A}, {E, C, B, A}, {D, C, B, A}
Concept Competitor (c)	{B, A}, {E, B, A}, {D, B, A}, {C, B, A}, {E, D, B, A}, {E, C, B, A}, {D, C, B, A}
Normalized PB index R1	0.09090909 0.18181818 0.18181818 0.27272727 0.27272727
Normalized PB index R2	0.1 0.1 0.1 0.3 0.4
Normalized PB index c	0.0 0.0 0.0 0.5 0.5
SS index R1	0.1000000 0.1833333 0.1833333 0.2666667 0.2666667
SS index R2	0.08333333 0.08333333 0.08333333 0.25000000 0.50000000
SS index c	0.0 0.0 0.0 0.5 0.5
Success prob, indep pref, behind veil, R1/R2/c	0.5385124 / 0.5378188 / 0.5343319
Success prob, indep pref, per group R1	0.531323 / 0.5471015 / 0.5389068 / 0.5422752 / 0.5346674
Success prob, indep pref, per group R2	0.5315122 / 0.5236948 / 0.5194424 / 0.5423237 / 0.5462195
Success prob, indep pref, per group comp	0.5001042 / 0.5001818 / 0.4999439 / 0.5564911 / 0.5462308
Success prob, aligned pref, behind veil, R1/R2/c	0.6634563 / 0.6726945 / 0.6700662
Success prob, aligned pref, per group R1	0.5625175 / 0.62493 / 0.6245855 / 0.6875055 / 0.6873985
Success prob, aligned pref, per group R2	0.56222 / 0.5622215 / 0.561877 / 0.687208 / 0.750107
Success prob, aligned pref, per group comp	0.5000495 / 0.500051 / 0.4997065 / 0.7493785 / 0.7501495
Error term according R1 (method 1, PB) R1/R2/c	0.02617178 / 0.07484115 / 0.2017992
Error term according R2 (method 1, SS) R1/R2/c	0.09257286 / 0.06799451 / 0.1492592
Coeff var according R1 (method 2, PB) R1/R2/c	0.1173041 / 0.2767331 / 0.6948053
Coeff var according R2 (method 2, SS) R1/R2/c	0.3623343 / 0.255115 / 0.7226806

B.2 Further Information on the Selection of the Decision Situations Used in the Experiment

As written above, all voting systems corresponding to the rules in this experiment are correspond to this rule according to both of the methods shown in Section 2. In order to find suitable decision situations, a computer program went through (a subset of) all admissible voting systems for all kinds of possible group compositions. The programming has been done in the languages R and C. Note that the optimization procedure can be computationally quite expensive, because the number of possible sets of winning coalitions grows fast with the number of groups (for N groups, the set of all coalitions has 2^N elements and the set of all different sets of coalitions has 2^{2^N} elements). The programming has been done in a way that the computations can be performed on a simple notebook.

Only groups with an odd number of members were considered,, the groups cannot be too large and the number of winning coalitions was kept constant across comparisons, as explained in Section 3.6. All the different decision situations have been selected in a way that the recommended rules are not only the same according to both methods and different from each other, but also in a way that each system does not do too well in terms of the other rule and a 'competitor', i.e. a voting system not prescribed by any reasonable normative rule, has been added that does not do well according to both rules. In more detail, the selection procedure has been done as follows. For each fixed combination of number of groups, number of members per group, and number of winning coalitions the terms that are needed to select the voting system according to both rules and both methods described in Section 2 were calculated. Next, all situations were dismissed where the two different methods described in Section 2 do not yield the same unique outcome (separately for Rule I and Rule II). Then, situations were dismissed where the recommendations of Rule I and Rule II coincide. One also wants these recommendations not to be too similar in terms of 'performance' according to the respective other rule. Therefore, only voting systems were considered where the respective error terms differ enough. The system recommended by Rule I has at least 15% higher error terms in expressions (5) and (6) than the voting system recommended by Rule II. Vice versa, the Rule II system has similarly higher error terms in expressions (2) and (3) than the Rule I system. The competitor similarly has higher error terms when compared to each of the two rules. The number of 15% might seem a bit arbitrary – it is chosen as high as possible so that it is still possible to have some variety in terms of group constellations, given the constraints on group size to be feasible in the laboratory. More information on the computer programs is available on request.

B.3 Additional Graphs and Data

Figure 23 shows the proportion of people choosing one voting system predominantly. This graph is similar to Figure 3, but it also includes the graphs if one considers a system to be chosen predominantly only if it has been chosen at least 10 or 11 out of 12 times.

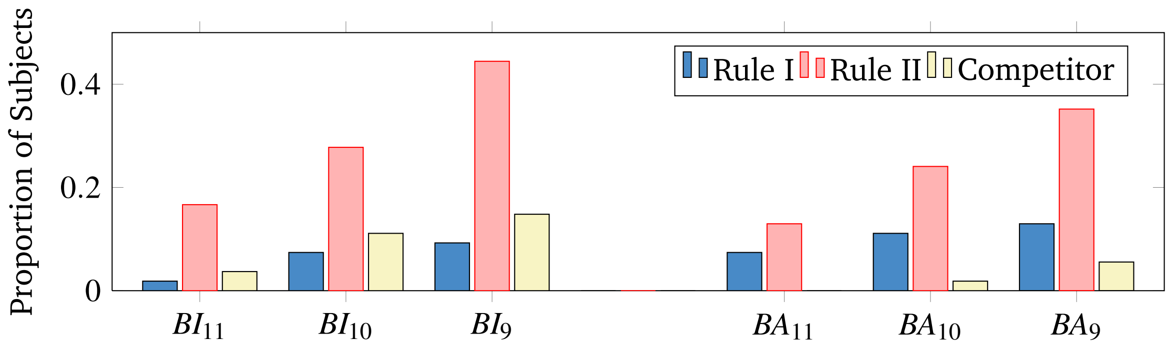
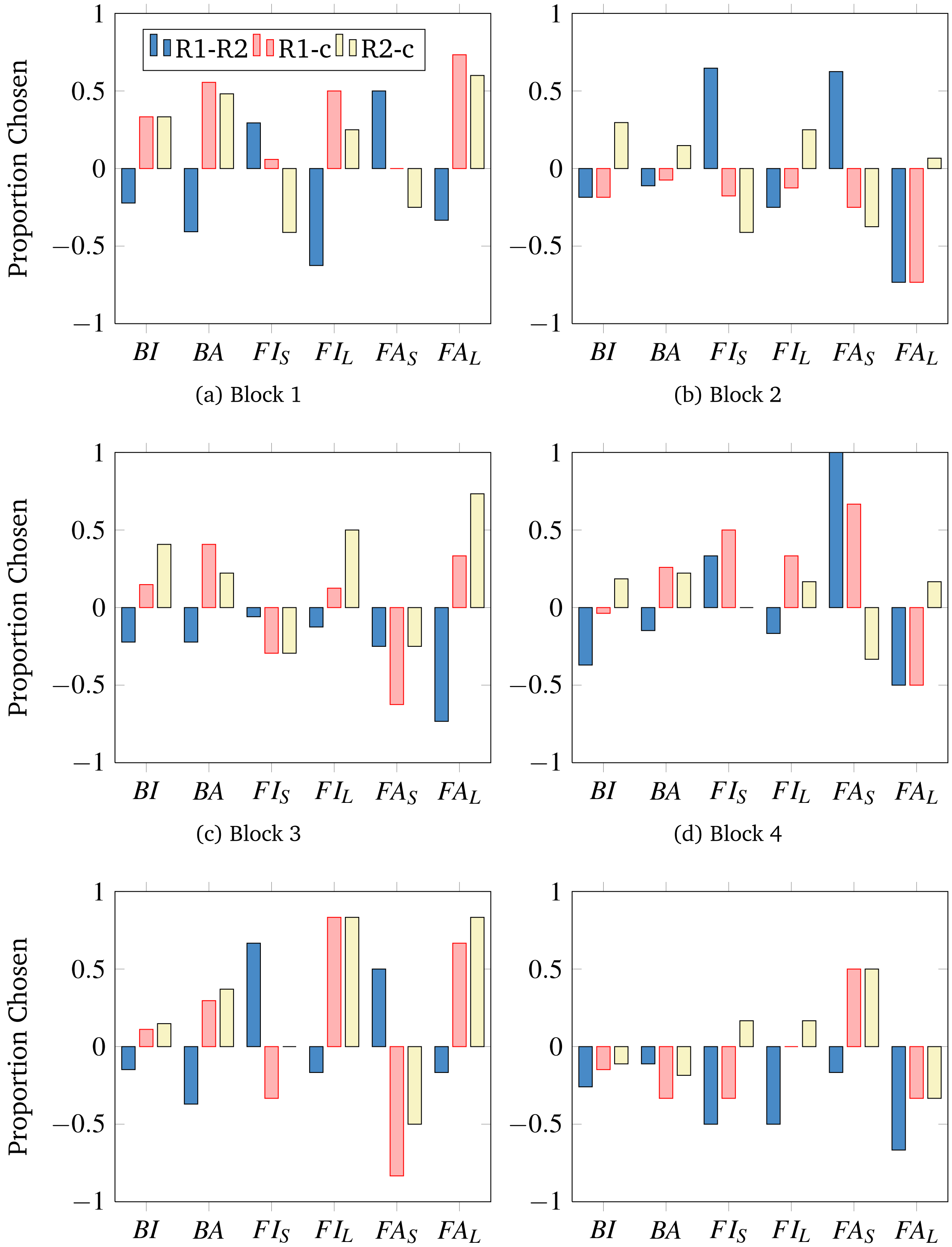


Figure 23: Proportion of Participants Choosing one System Predominantly

Notes: The figure shows the proportion of participants that choose one system predominantly. BI_{11} shows how many participants choose a system at least 11 out of 12 possible times in treatment BI, etc.

Figure 24 shows the choices of participants in all six decision blocks. Each of the six graphs (a) to (f) represents one block (the block number corresponds to the order of blocks as in Table 2, not to the order as the blocks appeared in the experiment, which is random). In each graph, the treatments are drawn next to one another. For the in front of the veil treatments, the data has been split up according to which group a participant will be in for payment if her choices are selected. Only the choices of the participants of the smallest (FI_S and FA_S) and largest (FI_L and FA_L) groups are depicted here (the numbers of observations then drop to between 10 and 17). The bars show how a voting system has been chosen over another one: The bar 'R1-R2' shows how often the system recommended by Rule I has been chosen over the system recommended by Rule II, the bar 'R1-c' shows how often the system of Rule I has been chosen over the respective additional competitor of the block, similarly for 'R2-c'. The scale used is difference in proportion, i.e. if the Rule II voting system has been chosen 70% of times in comparison with the corresponding Rule I voting system, the value of the corresponding bar 'R1-R2' would be −0.4 (the difference between 0.3 and 0.7). The data underlying this graph can be found in Table 24.

Table 2 shows, split up according to decision block and treatment (and group for the in front of the veil treatments), how often one voting system was preferred over both other voting systems.



(a) Block 1 (b) Block 2 (c) Block 3 (d) Block 4 (e) Block 5 (f) Block 6

Figure 24: Overview of the Data

Notes: The sub-figures (a) to (f) show the choices of participants in each decision block. The bars 'R1-R2' show how often voting systems according to Rule I have been chosen over voting systems according to Rule II (similar for 'R1-c' and 'R2-c'). These choices are shown for all subjects in treatments *BI* and *BA* and for the subjects of the smallest and largest groups in treatments *FI* and *FA* (FI_S, FI_L, FA_S, and FA_L, respectively).

Table 11: Data Choice Proportions

Treat.	Choice	Block 1	Block 2	Block 3	Block 4	Block 5	Block 6
BI	R1-R2	0.3888889	0.4074074	0.3888889	0.3148148	0.4259259	0.3703704
(54)	R1-c	0.6666667	0.4074074	0.5740741	0.4814815	0.5555556	0.4259259
	R2-c	0.6666667	0.6481481	0.7037037	0.5925926	0.5740741	0.4444444
BA	R1-R2	0.2962963	0.4444444	0.3888889	0.4259259	0.3148148	0.4444444
(54)	R1-c	0.7777778	0.462963	0.7037037	0.6296296	0.6481481	0.3333333
	R2-c	0.7407407	0.5740741	0.6111111	0.6111111	0.6851852	0.4074074
FI_A	R1-R2	0.1875	0.375	0.4375	0.4166667	0.4166667	0.25
(16/12)	R1-c	0.75	0.4375	0.5625	0.6666667	0.9166667	0.5
	R2-c	0.625	0.625	0.75	0.5833333	0.9166667	0.5833333
FI_B	R1-R2	0.1818182	0.8181818	0.7272727	0.09090909	0.2727273	0.4545455
(11/11)	R1-c	0.2727273	0.6363636	0.9090909	0.72727273	0.6363636	0.4545455
	R2-c	0.6363636	0.8181818	0.8181818	0.90909091	0.8181818	0.4545455
FI_C	R1-R2	0.7142857	0.5714286	0.71428571	0	0.3636364	1
(14/11)	R1-c	0.7142857	0.4285714	0.42857143	0	0.2727273	1
	R2-c	0.2142857	0.6428571	0.07142857	0.6363636	0.2727273	0.9090909
FI_D	R1-R2	0.6470588	0.8235294	0.4705882	0.58333333	0.8333333	0.9166667
(17/12)	R1-c	0.5294118	0.4117647	0.3529412	0.08333333	0.8333333	0.9166667
	R2-c	0.2941176	0.2941176	0.3529412	0.25	0.5833333	0.75
FI_E	R1-R2	NaN	NaN	NaN	0.6666667	0.8333333	0.25
(0/12)	R1-c	NaN	NaN	NaN	0.75	0.3333333	0.3333333
	R2-c	NaN	NaN	NaN	0.5	0.5	0.5833333
FA_A	R1-R2	0.3333333	0.1333333	0.1333333	0.25	0.4166667	0.1666667
(15/12)	R1-c	0.8666667	0.1333333	0.6666667	0.25	0.8333333	0.3333333
	R2-c	0.8	0.5333333	0.8666667	0.5833333	0.9166667	0.3333333
FA_B	R1-R2	0.18181818	0.9090909	0.9090909	0.3636364	0	0.36363636
(11/11)	R1-c	0.09090909	1	0.9090909	0.8181818	0.1818182	0.09090909
	R2-c	0.63636364	1	0.7272727	0.7272727	0.6363636	0.27272727
FA_C	R1-R2	0.7142857	0.4285714	0.6428571	0.1818182	0.3636364	0.8181818
(14/11)	R1-c	0.7142857	0.5	0.5	0.1818182	0.2727273	0.8181818
	R2-c	0.2857143	0.7142857	0.2857143	0.4545455	0.3636364	0.9090909
FA_D	R1-R2	0.75	0.8125	0.375	1	0.6	0.5
(16/10)	R1-c	0.5	0.375	0.1875	0.5	0.8	0.8
	R2-c	0.375	0.3125	0.375	0.4	0.7	0.8
FA_E	R1-R2	NaN	NaN	NaN	1	0.75	0.4166667
(0/12)	R1-c	NaN	NaN	NaN	0.8333333	0.08333333	0.75
	R2-c	NaN	NaN	NaN	0.3333333	0.25	0.75

Notes: This table shows the choices that the participants made, split up according to treatment and block, as illustrated in Figure 24. The numbers behind the treatment condition show the number of observation, where split up the first number refers to the first three blocks and the second number to the last three blocks.

Table 12: Counts of the Most Preferred Voting System per Block

Treatment	System	Block 1	Block 2	Block 3	Block 4	Block 5	Block 6
BI (54)	Rule I	12	15	8	11	9	13
	Rule II	28	22	27	23	22	11
	competitor	9	11	10	19	19	20
BA (54)	Rule I	11	19	13	17	13	15
	Rule II	34	16	27	21	27	5
	competitor	7	11	8	10	9	27
FI_A (16/12)	Rule I	2	5	5	4	5	2
	Rule II	9	5	9	3	6	5
	competitor	3	5	2	3	0	3
FI_B (11/11)	Rule I	1	7	7	1	1	2
	Rule II	5	2	3	9	8	4
	competitor	3	2	0	1	1	5
FI_C (14/11)	Rule I	6	6	4	0	1	11
	Rule II	1	4	1	7	2	0
	competitor	4	2	7	4	7	0
FI_D (17/12)	Rule I	5	6	3	0	9	10
	Rule II	5	2	4	2	2	0
	competitor	7	8	10	9	1	1
FI_E (0/12)	Rule I	NaN	NaN	NaN	7	3	3
	Rule II	NaN	NaN	NaN	3	2	4
	competitor	NaN	NaN	NaN	0	6	5
FA_A (15/12)	Rule I	4	1	1	1	4	2
	Rule II	8	8	11	6	6	3
	competitor	1	6	1	4	1	7
FI_B (11/11)	Rule I	1	10	10	4	0	1
	Rule II	6	1	0	6	7	3
	competitor	4	0	1	1	4	7
FI_C (14/11)	Rule I	6	5	4	1	0	7
	Rule II	3	7	3	5	3	2
	competitor	4	1	6	4	6	1
FI_D (16/10)	Rule I	5	5	1	5	5	5
	Rule II	4	2	4	0	3	3
	competitor	6	7	8	5	0	1
FI_E (0/12)	Rule I	NaN	NaN	NaN	10	1	4
	Rule II	NaN	NaN	NaN	0	2	5
	competitor	NaN	NaN	NaN	2	8	0

Notes: For each treatment condition and decision block, this table shows how many participant preferred each system over the other two. Numbers in parentheses behind the treatment are the number of observations, If there are two numbers the first one refers to the first three blocks, the second number to the last three.