Voting And Costly Information Acquistion – An Experimental Study

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1 Introduction

Elections under majority rule are everyday business in modern democracies. Whether it is small scale as electing the chairman of a sports club or large scale when electing governments or casting a vote in a referendum. When looking at the big elections of the last years, be it the election of the European Parliament of 2004 or the Bundestagswahl of 2005, one can observe declining voter turnout. This is why e.g. Australia has introduced mandatory voting. The main reason for mandatory voting is to ensure that governments represent a majority of the population and not only those parts of the population that want to express their opinions. But there are also arguments against compulsory voting, e.g. especially people who are not interested in politics resent the idea of being forced to vote. Exactly this point raises an interesting question about compulsory voting. People who are not interested in politics are usually not very well informed about political issues. When those people are forced to vote, how do they vote? Do they inform themselves about political issues before voting or do they vote randomly? Or does voluntary voting constitute a better solution as uninterested uninformed people have the chance to abstain?

There are only few models in the literature which address this question, such as Krasa and Polborn (2004), who compare among other the effects of mandatory and voluntary voting in a

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costly voting model. Most of the existing voting models are based on the assumption, that every voter already has a piece of information about which outcome of the election would be best. But, as already acknowledged by Downs (1957) voting is costly in some way and that those costs originate from the process of information gathering, be it measured in money or time. When costs are involved in most models they are attached to the voting process itself (e.g. Börgers, 2004), seldom to the act of becoming informed as in Martinelli (2004).

In this work we will develop a simple common values voting model with endogenous private information in order to examine if compulsory and voluntary voting have different influence on the information acquisition behaviour of voters and consequently on the information aggregation properties of the simple majority rule. We will show that both forms of voting institutions have indeed different incentives for voters to acquire information and thus different effects on the information aggregation properties of majority rule voting.

In a next step, we will design and conduct an experiment which we want to examine with whether or not our model is able to predict the actual behaviour of individuals. To our knowledge, this is the first experiment examining the information acquisition behaviour under different voting institutions. The results we gather from the experiment are surprisingly clear.

In the next section we will give a short survey on the literature which our work is based upon and the motivation for it stems from. In section 3 the theoretical model of the voting game with costly information acquisition is developed in three steps, starting with the classic Condorcet model and extending it further, first by introducing costly private information and then by permitting abstention, in order to be able to answer the question at hand. After that, we will briefly compare the models and their ability to aggregate information. In section 4 the experimental set-up and design are presented followed by the analysis of the results in section 5. The last section concludes with a summary of the insights this work conveys and an outlook on what could be subject to further research in the future.

2 Related Literature

The literature related to this work deals with the information aggregation in group decisions, the question of abstention in voting processes and the existence of costly information. A very good recent survey of the literature about decision making and information acquisition is

Gerling et al. (2003). They summarize the most important aspects of the topic including strategic voting, abstention and incentives for information acquisition.

One of the first models applying a game-theoretic approach to the group decision process and introducing the notion of strategic voting is Austen-Smith and Banks (1996). It is shown that under some circumstances the information aggregation of group decisions are no longer valid.

Feddersen and Pesendorfer (1996) introduce a model of a two-candidate election with private information and common values. They model two different kind of voters: informed and uninformed voters. The informed voters know the true state of the world with absolute certainty, while the uninformed voters only have a prior belief about the true state of the world. Although the prior belief of the uninformed voter is a strict preference for one of the candidates they show that the uninformed voter has an incentive to abstain, although voting is costless, so that an informed voter is always more likely to vote than an uninformed voter. They call it the “swing voter’s curse”. Feddersen and Pesendorfer (1996, p. 418) are also the first suggesting to introduce endogenous information to voting model. However, at the same time they argue this extension to be of little interest as only voters with information cost zero would acquire information. Feddersen and Pesendorfer (1997) examine voter behaviour in a two-candidate election, where all voters are uncertain about the true state of the world. They find that when individuals vote strategically information is aggregated effectively. Feddersen and Pesendorfer (1998) introduce another two candidate model with costless voting. Preferences are diverse and abstention is possible. They find that despite a fraction of the electorate will abstain, the election still effectively aggregates the private information of the voters.

There are several papers which concern themselves with endogenizing information in voting models. One of them is Persico (2004) which deals with two parameters that determine the incentive to acquire information. The first one is the size of the electorate. The second parameter is the voting rule. The model is also a binary voting model, where a so called mechanism designer picks the the size of the jury and sets the voting rule. Information in this model is costly and the costs are fixed. The model is analysed to find the optimal jury size and the optimal voting rule. A similar approach to analysing the information aggregation properties of electorates by altering group size is chosen by Yariv (2004). Information is costless, but abstention is allowed.

Another model of costly private information is Mukhopadhaya (2003) where the information of a jury member depends on the size of the jury. It uses the illustrative image of the juror who pays less attention as the jury gets larger, thus presenting information acquisition as a free-rider problem. Jurors can pay attention and become informed at fixed cost. When nobody pays attention the decision made is incorrect. In the basic version of the model the information is perfect. In the extension of the model the signal is imperfect in the sense that it does not reveal the true state of the world with absolute certainty. The uninformed jurors have a chance of observing the voting decision of the informed jurors so they can base their decision on that information. The result of this model is that when information is costly the smaller jury performs better as it makes fewer mistakes. The probability of paying attention decreases in jury size.

Martinelli (2004) develops a model of costly information aggregation, where the cost is not fixed and the quality of the information about the true state of the world depends on how much an individual spent for it. Abstention is not allowed in this model. It is a formal model of rational ignorance hypothesis stated by Downs (1957, p.246), according to which each individual who realizes that her vote has negligible effect on the outcome of the election will invest little or nothing in the acquisition of information. This result will play an important role in the later analysis of our own model. In contrast to Mukhopadhaya (2003) in the model of Martinell (2004) increasing the group size does increase group performance.

Feddersen and Sandroni (2004) choose a totally different approach and deviate from the path of game theoretic and statistical models to develop a model of ethical voters who vote out of a sense of civic duty. They show that a significant fraction of the electorate acquires information, although even with negligible costs, a portion of the electorate still remains uninformed.

Börgers (2004) describes a model of costly participation and private values where they identify an important negative externality of participation. Ghosal and Lockwood (2003) pick up that idea and examine costly voting in a common value environment, finding an additional positive informational externality which tends to outweigh the negative participation externality. In a different approach with a combination of private values and heterogenous beliefs Ghosal and Lockwood (2004) find excessive participation.

There have been few experimental studies on information aggregation in group decisions. Guarnaschelli et al. (2000) conducted experiments on jury decision to test the theory developed by Feddersen and Pesendorfer (1998) and their finding that juries perform better under unanimous rule than under majority rule. The experiments reveal tendencies to vote strategically under unanimous rule and that the theoretical predictions are roughly accurate. Another experiment by Ladha et al. uses a special design that causes strategic voters to vote insincerely, i.e. not according to the signal they receive. The purpose of this design was to find out if juries solve a coordination problem: Because every jury member voting insincerely would lead to inferior outcomes the members had to coordinate who the insincere voter would be. The results show that most of the groups managed to coordinate and thus the groups performed better than any individual.

While there has been recent work concentrating on costly acquisition of private information and the possibility of abstention seperately, there is no known paper which puts those two aspects togethet. In the following section, we will develop, step by step, a model which incorporates both costly private information and the possibility of abstention.

3 The Voting Game With Costly Information Acquisition

In this section we will, step by step, develop the model which is to answer the question of whether elections aggregate private costly information when abstention is possible. In the first subsection, a game theoretic approach to the Condorcet Jury Theorem will be introduced as a starting point of our analysis. Next, the model will be extended by introducing costly private information. And finally, the model will be further refined by permitting abstention.

3.1 The Condorcet Jury Theorem

The first, and most famous, approach to information aggregation in committee decision-making, and the starting point of our analysis, is the Condorcet Jury Theorem (CJT), developed by Marquis de Condorcet in 1785.[2] This theorem states, in short, that in a binary decision situation, where two alternatives A and B exclude each other and all individuals share common values, i.e. all individuals prefer one of these alternatives over the other, a

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[2] For a discussion of the Condorcet Jury Theorem, see Miller (1986), Young (1988) and Ladha (1992).

group performs better in deciding which alternative to choose under majority rule than any one individual does, i.e. the probability of the group choosing the correct alternative is larger than any individual's. Furthermore, the probability of the majority of the group voting for the better alternative approaches 1 as the group size goes to infinity (Black, 1958, 164f.) which according to Picketty (1999, p. 793) is "a trivial consequence of the law of large numbers, but it is powerful." The original work of Condorcet was merely a statistical model which assumed that every individual in the electorate makes the decision as if she were acting alone. This assumption was often criticised in recent literature such as Austen-Smith and Banks (1996) who presented a game theoretic approach which introduced the notion of strategic voting, where each individual takes into account the behaviour of every other individual when making her own decision.

3.1.1 The Basic Model

The following model and its solution are based on the descriptions by Austen-Smith and Banks (1996) and Wit (1997). There are two possible states of the world A and B, with $S = \{A, B\}$ denoting the set of states. There is also a group of n individuals, $N = \{1,2,\ldots,n\}$; assume n is odd. None of these individuals knows the true state of the world, but all of them hold a prior belief π $(0 < \pi < 1)$ that the true state is A, and a prior belief $1-\pi$ that the true state is B. Because individuals are initially totally uncertain about the true state of the world, assume that $\pi = \frac{1}{2}$.

Further, there are two proposals, also labelled A and B, with $X = \{A, B\}$ denoting the set of alternatives. Each of the n individuals has to vote for one of these proposals. All individuals vote simultaneously, so no individual knows the vote of any other individual until all votes are cast. The proposal being chosen is determined by majority rule, i.e. the proposal which receives the most votes from the entire group is chosen.[3]

Individuals have common values, i.e. their preferences regarding the proposal being chosen are identical. Every individual prefers the group choosing proposal A when the true state of

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[3] More generally speaking, the proposal which receives at least $\frac{n-1}{2}$ (more than one half) of the votes is chosen by the group.

the world is A, and choosing proposal B when the true state of the world is B. Formally, for each individual $i \in N$ this is described by the utility function $U_i : X \times S \mapsto R$:

$$U_i(A,A) = U_i(B,B) = 1 \text{ and } U_i(A,B) = U_i(B,A) = 0 .$$

The first argument of the function describes the alternative being chosen by individual i and the second argument describes the true state of the world. Thus, if the selected alternative and the true state of the world are the same, individual i receives a utility of 1, otherwise she receives a utility of 0.

Before individuals actually vote, each of them receives a private signal t_i from the signal space $T = \{a,b\}$. The signal an individual receives determines that individual's type. The signals are drawn independently from a state-dependent distribution with

$$P[t_i = a \mid A] = q_a \in \left(\frac{1}{2},1\right] \text{ and } P[t_i = b \mid B] = q_b \in \left(\frac{1}{2},1\right],$$

so that it is more probable to observe signal a in state A and to observe signal b in state B, that is q_a and q_b are the probabilities of signal a and b, respectively, revealing the true state of the world. Assume that $q_a = q_b = q$, i.e. the accuracy of both signals, given the true state of the world, is the same. The individuals do not communicate their private signals to others, so they only choose the proposal to vote for on the basis of their prior belief, which is common knowledge, and their own private signal. The assumption of not allowing communication is a stylized description of situations with costly communication, such as an experts committee where the members are in different physical locations (see Persico, 2004, p.170). Often, it simply takes time to communicate one's opinion which represents a cost as well. If perfect communication were costless the voting mechanism would be "an immaterial veil that members see through."

To summarize, the timing of this basic model is as follows:

1. The state of the world s is realized.
2. Every individual i receives a private signal t_i which reveals the true state of the world with probability q (this signal determines i's type).

3. Every individual i must vote for either alternative A or B.
4. The alternative which received the most votes is selected (simple majority rule) and the individuals receive a utility according to the correctness of the group decision.

The voting game described above is a static game with incomplete information, also called Bayesian game.[4]

3.1.2 Equilibrium Behaviour

We now turn to the voting strategy an individual i is going to adopt in this voting game. In doing so, we follow the derivation of Wit (1997; pp. 73) while adjusting his rather general model to our specific model parameters.[5]

An individual's voting strategy is a function σ_i from the space of functions $\Sigma : T \mapsto [0,1]$. This function relates to every individual i a probability of voting for proposal A when i's type is a and a probability of voting for proposal B when i's type is b. Following Feddersen and Pesendorfer (1996, p.412) we only consider symmetric strategies, i.e. individuals of the same type (receiving the same signal) use the same strategy. Thus, we can write

$$\sigma_i(a) \equiv p_a \text{ and } \sigma_i(b) \equiv p_b .$$

All those strategies of every individual i taken together constitute a strategy profile $\sigma = (\sigma_1, \sigma_2, \sigma_3, \ldots, \sigma_n)$. In order to find the equilibrium strategy for each individual i, we adopt the concept of Bayesian Nash Equilibrium as defined in Wit (1997, p. 71): "A Bayesian Nash Equilibrium is a strategy profile σ^* such that

$$E\left[U_i \middle| \sigma_i^*, \sigma_{-i}^*, t_i\right] \geq E\left[U_i \middle| \sigma_i, \sigma_{-i}^*, t_i\right] \text{ ,} \forall i \in N, \sigma_i \in \Sigma, t_i \in T \text{ ."}$$

Each individual's strategy must be a best response to the other players' strategies. Each individual i, given the optimal strategies σ_{-i}^* of every individual other than i, chooses for

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[4] For a detailed description of the notion of a Bayesian game and its normal-form representation, see e.g. Gibbons (1992, pp. 143-149) or Osborne (2004, pp. 278-280).

[5] The derivation of Wit (1997) is closely related to that of Austen-Smith and Banks (1996), who only check for pure strategies, though. Wit (1997) also derives a mixed-strategy solution.

every possible type t_i of i a strategy σ_i^* such that her expected utility is equal or larger than the expected utility resulting from any other strategy σ_i that i could choose. Because this condition must hold for every individual i, no individual wants to change her strategy.[6]

The Bayesian Nash Equilibrium condition can be simplified by considering that in voting games like this an individual is only concerned with her strategy in situations where she is pivotal, i.e. situations where the individual's particular vote makes a difference in determining the outcome of the group decision.[7] Under majority rule, this occurs only when the other individuals generate a tie situation: one half of the others ($\frac{n-1}{2}$) votes for alternative A and the other half ($\frac{n-1}{2}$) votes for alternative B. As in Wit (1997, p. 71), we define $Piv_i(\sigma_{-i})$ as the event of voter i being pivotal given that the others use strategy σ_{-i}. Thus, the reduced equilibrium condition is

$$E\left[U_i \middle| \sigma_i^*, Piv_i\left(\sigma_{-i}^*\right), t_i\right] \geq E\left[U_i \middle| \sigma_i, Piv_i\left(\sigma_{-i}^*\right), t_i\right], \forall i \in N, \sigma_i \in \Sigma, t_i \in T .$$

This condition is trivially satisfied if all other individuals ignore their signal and vote for alternative A, i.e. $\sigma_j(a) = 1 - \sigma_j(b) = p_a = 1 - p_b = 1, \forall j \neq i$ or if all other individuals ignore their signal and vote for alternative B, i.e. $\sigma_j(a) = 1 - \sigma_j(b) = p_a = 1 - p_b = 0, \forall j \neq i$. According to Ghosal and Lockwood (2003, p. 7) this is a weakly dominated strategy and can be eliminated. There are other strategy profiles which satisfy the equilibrium condition and make any individual pivotal in certain situations.

First, we need to compute the expected utility of voting for either alternative for individual i. In order to do that, the probability of the state s being the true state of the world, given individual i has received signal t_i and is pivotal, needs to be calculated using Bayes' rule:[8]

[6] Different formulations of the definition of a Bayesian Nash Equilibrium can e.g. be found in Gibbons (1992, p. 151) or Osborne (2004, p. 281-282).

[7] By situation we refer to the particular list of actions that the other individuals take.

[8] A derivation and definition of Bayes' rule as well as an illustrative example can be found in Osborne (2004, pp. 502-504).

$$P\left[s \middle| Piv_i\left(\sigma_{-i}^{*}\right), t_i\right] = \frac{P[s]P\left[Piv_i\left(\sigma_{-i}^{*}\right), t_i \middle| s\right]}{P\left[Piv_i\left(\sigma_{-i}^{*}\right), t_i\right]}.$$

Individual i's expected utility of voting for alternative A given the signal received and being pivotal can thus be computed as

$$\begin{aligned} E\left[U_i(A,s) \middle| Piv_i\left(\sigma_{-i}^{*}\right), t_i\right] &= U_i(A,A)\frac{P[s=A]P\left[Piv_i\left(\sigma_{-i}^{*}\right), t_i \middle| s=A\right]}{P\left[Piv_i\left(\sigma_{-i}^{*}\right), t_i\right]} \\ &+ U_i(A,B)\frac{P[s=B]P\left[Piv_i\left(\sigma_{-i}^{*}\right), t_i \middle| s=B\right]}{P\left[Piv_i\left(\sigma_{-i}^{*}\right), t_i\right]} \\ &= \frac{\frac{1}{2}P\left[Piv_i\left(\sigma_{-i}^{*}\right), t_i \middle| s=A\right]}{P\left[Piv_i\left(\sigma_{-i}^{*}\right), t_i\right]}. \end{aligned}$$

Similarly, individual i's expected conditional utility of voting for alternative B can be calculated:

$$E\left[U_i(B,s) \middle| Piv_i\left(\sigma_{-i}^{*}\right), t_i\right] = \frac{\frac{1}{2}P\left[Piv_i\left(\sigma_{-i}^{*}\right), t_i \middle| s=B\right]}{P\left[Piv_i\left(\sigma_{-i}^{*}\right), t_i\right]}.$$

Individual i now has to compare these expected utilities to decide which strategy to choose. She will vote for alternative A if

$$E\left[U_i(A,s) \middle| Piv_i\left(\sigma_{-i}^{*}\right), t_i\right] > E\left[U_i(B,s) \middle| Piv_i\left(\sigma_{-i}^{*}\right), t_i\right],$$

and she will vote for alternative B if

$$E\left[U_i(A,s) \middle| Piv_i\left(\sigma_{-i}^{*}\right), t_i\right] < E\left[U_i(B,s) \middle| Piv_i\left(\sigma_{-i}^{*}\right), t_i\right].$$

When both expected utilities are equal individual i is indifferent between the two alternatives and will adopt a mixed strategy.[9]

We define a function $w(t_i)$ which measures for each t_i individual i's proportional difference between the expected utility of voting for alternative A and voting for alternative B, given both the signal received and i being pivotal:[10]

$$w(t_i) = E\left[U_i(A,s) - U_i(B,s) \middle| Piv_i\left(\sigma^*_{-i}\right), t_i\right] \ P\left[Piv_i\left(\sigma^*_{-i}\right), t_i\right]$$
$$= \frac{1}{2} P\left[Piv_i\left(\sigma^*_{-i}\right), t_i \middle| s = A\right] - \frac{1}{2} P\left[Piv_i\left(\sigma^*_{-i}\right), t_i \middle| s = B\right]$$

Furthermore, because the probability of receiving signal t_i and the probability of being pivotal are independent $P\left[Piv\left(\sigma^*_{-i}\right), t_i \middle| s\right] = P\left[Piv\left(\sigma^*_{-i}\right)\middle| s\right] \cdot P\left[t_i \middle| s\right]$ and the probability of an individual i being pivotal when the other $n-1$ individuals adopt the strategies σ^*_{-i}, given state s, is

$$P\left[Piv_i\left(\sigma^*_{-i}\right)\middle| s\right] = \sum_{k=0}^{n-1} \sum_{j=0}^{\min\left(\frac{n-1}{2},k\right)} \binom{n-1}{k} P[a|s]^k \left(1 - P[a|s]\right)^{n-1-k}$$
$$\times \binom{k}{j} p_a^j \left(1-p_a\right)^{k-j} \binom{n-1-k}{\frac{n-1}{2}-j} \left(1-p_b\right)^{\frac{n-1}{2}-j} p_b^{\frac{n-1}{2}-k+j} .$$

This formula looks rather complicated, so we describe it in detail. The number k of individuals receiving signal a can be any number between 0 and $n-1$. It follows that $n-1-k$ individuals receive signal b. Now in order to make individual i pivotal, one half of the other individuals must vote for alternative A and the other half must vote for alternative B, so when j of the k a-types vote for alternative A then $\frac{n-1}{2} - j$ of the b-types must also

[9] A mixed strategy is a probability distribution over feasible actions, which in our context are "voting for alternative A" and "voting for alternative B". For a detailed description of the notion of mixed strategies and an illustrating example, refer to Gibbons (1992, p. 29-33).

[10] We are only interested in the sign of the difference (or if it is zero), not in the magnitude of the difference. That is why it suffices to consider the function $w(t_i)$.

vote for alternative A.[11] The remaining $k-j$ a-types and $\frac{n-1}{2}-k-j$ b-types vote for alternative B.[12] The number of a-type individuals cannot be larger than the number of a-types k or larger than one half of the other individuals, that is $\frac{n-1}{2}$.

As Wit (1997, p.107) shows, in equilibrium, the probability of an a-type individual voting for alternative A is strictly larger than the probability of a b-type individual voting for alternative A ($p_a > 1-p_b$), which implies $w(a) > w(b)$. This finding precludes the possibility of both types of individuals using a mixed strategy: The equilibrium condition of any type t_i using a mixed strategy is $w(t_i)=0$. Both types using a mixed strategy thus would mean $w(a)=0$ and $w(b)=0$, which in turn violates the relationship $w(a) > w(b)$. So we still need to examine the possible equilibria in pure strategies ($p_a = p_b = 1$) and in, as Wit (1997, p. 73) calls them, "hybrid strategies", where one type adopts a pure strategy and the other type adopts a mixed strategy ($p_a = 1$ and $0 < p_b < 1$, or $p_b = 1$ and $0 < p_a < 1$).

We first turn to the pure strategies equilibrium. When individuals adopt the strategies $p_a = 1$ and $p_b = 1$, they vote according to the signal they received. Following Persico (2004, p. 171) we say that when an individual's vote replicates her signal she votes sincerely.[13] The equilibrium conditions in this case are $w(a) > 0$ and $w(b) < 0$,[14] which are always satisfied.

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[11] Remember that p_a is the probability of an a-type individual to vote for alternative A and $(1-p_b)$ is the probability of a b-type individual to vote for alternative B. Consequently $(1-p_a)$ is the probability of an a-type individual to vote for alternative B and p_b is the probability of a b-type individual to vote for alternative B.

[12] When there are $n-1-k$ individuals who receive signal b, $\frac{n-1}{2}-j$ of which vote for alternative B, the remaining b-types voting for alternative B result from $n-1-k-\left(\frac{n-1}{2}-j\right)=\frac{2n-2-n+1}{2}-k+j=\frac{n-1}{2}-k+j$.

[13] Some authors, such as Austen-Smith and Banks (1996) and Wit (1997), use the expression "informative" voting, when an individual votes in accordance with her signal, because the vote conveys information about the individual's signal to others. Moreover, Austen-Smith and Banks (1996, p. 36) use the expression "sincere" voting to describe an individual voting for the alternative yielding the higher expected utility, given her signal, if she alone were making the decision.

[14] The expected conditional utility of an a-type individual voting for alternative A must be larger than when voting for alternative B, hence $w(a) > 0$. Likewise, the expected conditional utility of a b-type individual voting for B must be larger than when voting for alternative A, hence $w(b) < 0$. In contrast to Wit (1997) we only allow for strict inequalities.

The conditions for the hybrid equilibrium $p_a = 1$ and $0 < p_b < 1$ are $w(a) > 0$ and $w(b) = 0$ and they are never met, as are the conditions for the hybrid equilibrium $p_b = 1$ and $0 < p_a < 1$. Thus, there exists no hybrid equilibrium in our model.[15]

As a result, we can conclude that individuals vote sincerely, i.e. every individual votes according to her signal. This result is also supported by Austen-Smith and Banks (1996) who show that under the assumptions that the conditional probabilities of the signals revealing the true state of world being the same for both states and that majority rule is the optimal voting rule, sincere voting is a Nash equilibrium.

The probability of a group of size n making the correct decision, i.e. selecting by majority rule the alternative which matches the true state of the world is

$$P[correct] = \sum_{k=\frac{n+1}{2}}^{n} \binom{n}{k} q^k (1-q)^{n-k} .$$

For the case $n = 3$ this is 0.84375, which is better than any individual deciding on her own. Thus, the main result of the CJT remains valid in a game theoretic framework. Using this formula it can be shown that for n becoming ver large the probability of the group selecting the correct alternative goes to 1.[16] The result of the individuals voting sincerely is an important basis for the analysis of the two extensions discussed in the next two sections.

3.2 Costly Information Acquisition

3.2.1 Extending the Model

We now extend our model by introducing costly private information. The assumptions of the model from section 3.1 remain with one exception: Until now, every individual received a signal about the true state of the world free of charge. In the following extension this information is costly where the cost c is fixed and the same for each individual. Every individual is free to choose whether to “acquire” information to update her belief about the

[15] Refer to Appendix A for a detailed proof of these statements.

[16] McLennan (1998) shows that when the size of the electorate is increased the probability of making a wrong decision goes to zero.

true state of world or not. Hence, only those individuals who choose to acquire information will receive a signal. This extension makes sense, because in reality members of an electorate, be it a committee selecting a chairman, a jury in court, or a nation electing a new government, must invest money or at least time to gather some information about a candidate, get informed about political issues, etc. in order to know which alternative would be best to vote for. In this first extension of the model, though, each individual must vote for either alternative, irrespective of her decision to acquire information and thus irrespective of them being informed or not. Mandatory or compulsive voting is used in many countries in government elections, such as Belgium, Turkey and Australia as well as most South American states (see Wikipedia, 2004).

The sequence of play in this extended model is as follows:

1. The state of the world s is realised.
2. Each individual $i \in N$ decides whether she acquires a signal t_i at cost c.
3. Every individual i who has decided to acquire a signal (whom we refer to as *informed* individuals), receives a signal t_i which reveals the true state of the world with probability q.
4. Every individual i, the informed as well as the uninformed, must vote for either alternative A or B.
5. The alternative which received the most votes is selected (simple majority rule) and the individuals receive a utility according to the correctness of the group decision.

This extended model is very similar to that of Mukhopadhaya (2003). It differs in that it assumes that the uninformed individuals can observe the votes of the informed individuals. In our model no kind of communication or observing the others' behaviour before the group decision is determined is allowed. The model as it is states above is states a dynamic game of incomplete information, so we need to look for a Perfect Bayesian Nash Equilibrium.[17]

[17] For an introduction of the concept of Perfect Bayesian Nash Equilibrium see e.g. Gibbons (1992, pp. 175-183). There, by presenting an easy example of a two-stage game, the requirements as well as a definition of the Perfect Bayesian Nash Equilibrium are developed.

3.2.2 Equilibrium Behaviour

As already made clear in section 3.1 an individual concerns herself only with those situations when she is pivotal. In any other case her vote wouldn't change the outcome of the election and neither would the individual's utility. Adopting the original general formula for the probability of being pivotal from Wit (1997, p. 73) and adjusting it to the fact that there are still uninformed individuals who must cast a vote, we obtain

$$P\left[Piv\left(\sigma_{-i}^{*}\right)\middle|s\right]=\sum_{k=0}^{n-1}\sum_{j=0}^{k}\sum_{l=0}^{\min\left(\frac{n-1}{2},j\right)}\sum_{m=0}^{\min\left(\frac{n-1}{2},k-j\right)}\binom{n-1}{k}p^{k}\left(1-p\right)^{n-1-k}$$

$$\times\binom{k}{j}P\left[a\middle|s\right]^{j}\left(1-P\left[a\middle|s\right]\right)^{k-j}\binom{j}{l}p_{a}^{l}\left(1-p_{a}\right)^{j-l}\binom{k-j}{m}\left(1-p_{b}\right)^{m}p_{b}^{k-j-m}$$

$$\times\binom{n-1-k}{\frac{n-1}{2}-l-m}\pi^{\frac{n-1}{2}-l-m}\left(1-\pi\right)^{\frac{n-1}{2}-k+l+m}.$$

The adjustments made to the original formula are the following: k denotes the number of the other individuals other than i choosing to acquire information, the other $n-1-k$ individuals choose not to acquire information, where p is the ex-ante probability of any individual acquiring information and $1-p$ the ex-ante probability of any individual not acquiring information. Because only the k informed individuals receive a signal, k is the upper bound for j, which is the number of individuals receiving signal a. Of these j a-type individuals l are voting for alternative A and $j-l$ are voting for alternative B. The number of a-type individuals voting for alternative A cannot be larger than the number of a-types j or larger than one half of the other individuals $\frac{n-1}{2}$. Of the remaining $k-j$ informed individuals, who are b-types, m are voting for alternative A and $k-j-m$ are voting for alternative B. The number of b-type individuals cannot be larger than the number of b-types $k-j$ or larger than half of the other individuals $\frac{n-1}{2}$. The $n-1-k$ uninformed individuals have to vote on the basis of their prior beliefs π. Because $l+m$ informed voters are already voting for alternative A, $\frac{n-1}{2}-l-m$ of the uninformed voters must vote for alternative A as well in order to make individual i pivotal.

Using backwards induction we analyse the last stage first, where the individuals have already made their decision on acquiring information and must now decide which alternative to vote for. Considering only symmetric strategies and applying the same analysis as in section 3.1.2 we obtain that $p_a = p_b = 1$,[18] i.e. the informed individuals all vote sincerely, that is according to their signal. The uninformed individuals only know, that when they are pivotal there are equal numbers of votes for either alternative. As this situation conveys to them no information about the true state of the world, they have to vote on the basis of their prior belief π. In our model $\pi = \frac{1}{2}$, so they are indifferent between voting for either alternative and adopt a mixed strategy voting for either alternative with probability $\frac{1}{2}$. Thus, the last term of $P\left[Piv\left(\sigma_{-i}^{*}\right)\middle| s\right]$ simplifies to $\binom{n-1-k}{\frac{n-1}{2}-l-m}\cdot\left(\frac{1}{2}\right)^{n-1-k}$. Because of $p_a = p_b = 1$ the terms of the sum in $P\left[Piv\left(\sigma_{-i}^{*}\right)\middle| s\right]$ can only be different from zero when $l = j$ and $m = 0$. Thus, it reduces to:

$$P\left[Piv\left(\sigma_{-i}^{*}\right)\middle| s\right] = \sum_{k=0}^{n-1}\sum_{j=0}^{\min\left\{k,\frac{n-1}{2}\right\}}\binom{n-1}{k}p^{k}(1-p)^{n-1-k}\times\binom{k}{j}P[A|s]^{j}\left(1-P[A|s]\right)^{k-j}\binom{n-1-k}{\frac{n-1}{2}-j}\cdot\left(\frac{1}{2}\right)^{n-1-k}$$

Furthermore, it no longer matters which particular signal the informed individuals receive conditional on the true state. It is only important that j individuals receive a signal in favour of one alternative and $k-j$ receive a signal in favour of the other. In the following, we will only distinguish between signals according to individual i's signal and signal opposing i's signal. Hence, we can substitute $P[A|s]$ with q and obtain the unconditional probability of being pivotal:

[18] The formula for $P\left[Piv\left(\sigma_{-i}^{*}\right)\middle| s\right]$ has only been extended by terms that are positive or zero, but they are strictly positive for some values of k. In the case $p = 0$, there are no informed individuals in stage 2 who can vote sincerely; in the case $p = 1$, there are no uninformed individuals, reducing the extended model to the original CJT model which has already been analysed in section 3.1.2. Thus, $p_a = p_b = 1$ constitutes a subgame-perfect Nash equilibrium for stage 2. So the analysis differs from that in section 3.1.2 in size alone, not in results.

$$P\left[Piv\left(\sigma_{-i}^{*}\right)\right]=\sum_{k=0}^{n-1}\sum_{j=0}^{\min\left\{k,\frac{n-1}{2}\right\}}\binom{n-1}{k}p^{k}(1-p)^{n-1-k}\binom{k}{j}q^{j}(1-q)^{k-j}\binom{n-1-k}{\frac{n-1}{2}-j}\cdot\left(\frac{1}{2}\right)^{n-1-k}.$$

In order to characterise individual i's equilibrium voting strategy, we have to calculate the gain from acquiring information relative to not acquiring information for every possible situation which she is pivotal in. When an individual does not acquire information about the true state of the world she only knows that the other (informed and uninformed) individuals generate a tie with their votes. From this fact alone, the individual cannot derive any further information about the state having to randomise her vote which leads to an expected utility from not acquiring information of $\frac{1}{2}$. This is true for every situation which she is pivotal in. By the formula for the probability of individual i being pivotal we already know every possible distribution of (the other) votes cast by both the informed and uninformed individuals which leads to a tie situation, making i pivotal. Each of these situations conveys information about the true state of the world. This information is contained in the signals the informed individuals receive, even in individual i's own signal. And because we already know that the informed individuals vote sincerely, by the vote they cast we also know their signal, hence enabling individual i to update her belief about the true state of the world. The uninformed individuals do not contribute any information about the true state, simply because they don't have any themselves.

When individual i acquires information she assumes that it represents the true state of world (with a probability 0.75). So for every possible situation that makes her pivotal she considers the number of signals that are in accordance with i's own signal (including her own) and the number of signals that are not. Each signal in accordance with i's own cancels out an opposing signal, so what matters is the difference between the number of different signals and the resulting informational advantage (or disadvantage) which allows for drawing conclusion from. For illustration, the following table gives an overview of the possible distribution of signals in tie situations for the case $n=3$:

other uninformed individuals	other informed individuals (k)	number $j+1$ of signals according	Total number

votes in accordance with i's signal	votes for opposite of i's signal	votes/signals in accordance with i's signal (j)	votes/signals oppositional to i's signal ($k-j$)	signals according to i's own signal (including i's signal)	of signals ($k+1$)
1	1	0	0	1	1
1	0	0	1	1	2
0	1	1	0	2	2
0	0	1	1	2	3

Table 1: Pivotal situations for individual i for $n=3$

In every possible situation where individual i is pivotal k other individuals acquire information (so there is a total of k other signals), j of which receive a signal in accordance with individual i's own. Considering i's own signal and adding it to the others' signals results in a total of $k+1$ signals, $j+1$ of which are in accordance with i's own.

To obtain the expected payoff from acquiring information for each of these situations separately, individual i has to observe the signals of each situation – of the other informed individuals as well as individual i's own – and calculate on the basis of these signals the posterior probability that the true state of the world is revealed by her signal. This probability conditional on observing $k+1$ signals, $j+1$ of which are in accordance with individual i's own signal is given by :[19]

$$\beta(j+1,k+1)=\frac{q^{j+1}(1-q)^{k+1-(j+1)}}{q^{j+1}(1-q)^{k+1-(j+1)}+(1-q)^{j+1}q^{k+1-(j+1)}}.$$

So, the gain from getting informed, conditional on having $k+1$ signals, $j+1$ of which are in accordance with individual i's signal, is $\beta(j+1,k+1)-\frac{1}{2}$. We can now derive the unconditional expected gain of getting informed by summing up the product of the probability of being pivotal in this situation and the conditional gain in this situation for each situation individual i is pivotal in:

[19] see e.g. Feddersen and Pesendorfer, 1998, p. 24

$$B(p)=\sum_{k=0}^{n-1}\sum_{j=0}^{\min\left(k,\frac{n-1}{2}\right)}\binom{n-1}{k}p^k(1-p)^{n-1-k}\binom{k}{j}q^j(1-q)^{k-j}\times\binom{n-1-k}{\frac{n-1}{2}-j}\cdot\left(\frac{1}{2}\right)^{n-1-k}\left(\beta(j+1,k+1)-\frac{1}{2}\right)$$

An individual will only acquire information when the gain of getting informed is greater than (or at least equal to) the cost. By setting $B(p)=c$ and solving for p we get the mixed strategy of acquiring information for any individual i.

From the discussion above we can now summarize the equilibrium behaviour of individual i: Each individual i acquires information (and receives a signal t_i with probability p. Each informed individual then votes sincerely, i.e. for alternative A upon receiving signal a and for alternative B upon receiving signal b. Each uninformed individual vote for either alternative with probability $\frac{1}{2}$.

When we apply the above derived formula to the group size $n=3$, set the probability of receiving the correct signal $q=0.75$, and set it equal to the cost $c=0.125$ then there are two possible solutions: $p=0.6154$ or $p=0$.[20]

In order to answer the question of how well compulsory voting in our context aggregates information, we have to calculate the probability that the group makes the correct decision. This probability given the equilibrium probability of any individual i acquiring information is

$$P[correct]=\sum_{i=0}^{n}\sum_{k=i-\frac{n-1}{2}}^{i}\sum_{l=\frac{n+1}{2}-i}^{n-i}\binom{n}{i}p^i(1-p)^{n-1}\binom{i}{k}q^k(1-q)^{i-k}\binom{n-i}{l}\left(\frac{1}{2}\right)^{n-i}$$

For the case $n=3$, $c=0.125$ and $p=0.6154$ this is 0.6208. It may surprise that the group is much less correct than any individual with $q=0.75$. This result does not at all support the statement of the CJT that groups perform better than individuals. On second thought, this result is not surprising at all, because in the CJT model there were no cost attached to the signals. By introducing cost not every member of the electorate receives a signal and only

[20] Here, we already applied the parameters we are going to use in the experiment. So these calculations not only serve as an illustrative example, but also as a basis for verifying the theoretical predictions of the model. A detailed outline of the calculations may be found in Appendix B.

votes with 50% accuracy of selecting the correct alternative, thus pushing down the group accuracy of choosing the correct alternative. By increasing the group size the probability of being pivotal will decrease, thus causing a lower a gain from acquiring information. This, in turn, causes the probability of information acquisition to drop dramatically fast to zero and hence the group accuracy will rapidly approach 50% as well. This result is in accordance with the finding of Börgers (2004) who identifies a negative externality of participation in a costly voting model. In addition there seems to be an additional negative informational externality induced by the uninformed individuals who are still forced to vote and reduce the gain from acquiring information even further.[21] The following tables present the equilibrium probabilities of acquiring information and the resulting probability of the group selecting the correct alternative for different values of the cost and different group sizes, the signal's accuracy q being held constant at 0.75..

$c = 0.125$	p	$P[correct]$
$n = 3$	0.61538	0.62080
$n = 5$	0.00000	0.50000
$n = 7$	0.00000	0.50000

Table 2: Group accuracy for $c = 0.125$

$c = 0.1$	p	$P[correct]$
$n = 3$	0.94201	0.82274
$n = 5$	0.54853	0.74452
$n = 7$	0.00000	0.50000

Table 3: Group accuracy for $c = 0.1$

The rate of information acquisition can only be raised by decreasing the cost. Compulsory voting only seems desirable when everyone (who is forced) already has information, i.e. the cost of information acquisition is zero. This result resembles that of Mukhopadhaya (2003) which says that smaller jurys make better decision. Feddersen and Pesendorfer (1996, p. 418) who also suggested endogenous information acquisition as an extension their own model already claimed that voters would only acquire information with costs zero, because the probability of being pivotal would be very small in an electorate of reasonable size. As a matter of fact, they already allowed for abstention in their model. So in the next section we will introduce the possibility of abstention to our model, making voting a voluntary act. After analysing this next extension we can compare compulsory and voluntary voting.

[21] This negative informational externality is in direct opposition to the positive informational externality identified by Ghosal and Lockwood (2003).

3.3 Abstention

3.3.1 The Abstention Extension

As a final extension of our model we introduce the possibility of abstention. All the model's existing assumptions remain, but now every individual is not only free to choose whether to acquire information about the true state of the world or not, but also whether to cast a vote for either alternative or abstain from voting. Individuals vote or abstain simultaneously. Because of the possibility to abstain, despite the assumption of n being odd, a tie may occur, so that the majority rule cannot be applied directly. In those cases, the majority decision is determined randomly by a "fair coin toss", i.e. each alternative is chosen with probability $\frac{1}{2}$.

This final extension is a logical step because despite the existence of mandatory voting in some countries like Belgium and Australia,[22] in most countries where governments are elected by the people abstention is indeed an option. And considering the decreasing voter turnout e.g. in Germany or in the election of the European Parliament, but also in North America over the last years, voters are obviously exploiting this option. The question we would like to answer is what effect the possibility of abstention has on the voters' the information acquisition behaviour and thus on the information aggregation properties of group decision.

The sequence of events in this abstention extension of our model is as follows:

1. The state of the world s is realised.
2. Each individual $i \in N$ decides whether she acquires a signal t_i at cost c.
3. Every individual i who has decided to acquire a signal (whom we refer to as *informed* individuals), receives a signal t_i which reveals the true state of the world with probability q.
4. Every individual i, the informed as well as the uninformed, may choose between voting for either alternative A or B or abstaining.
5. The proposal which received the most votes is selected (simple majority rule). If a tie occurs, i.e. an equal number of individuals vote for alternative A and for alternative B, the group decision is determined by a "fair coin toss": either proposal is selected with

[22] See Wikipedia (2004) for a complete list.

probability $\frac{1}{2}$. The individuals receive a utility according to the correctness of the group decision.

Again, the described game is a dynamic game of incomplete information which requires us to look for a Perfect Bayesian Nash Equilibrium.

3.3.2 Equilibrium Behaviour

Also, we again only consider symmetric equilibria, and as before individual i concerns herself only with those situations which she is pivotal in. As in section 3.2.2 we analyse the game by using backwards induction. The following line of argument is closely related to that of Ghosal and Lockwood (2003).[23]

We begin by analysing the last stage where individuals who decided to vote choose between proposal A and B. As this situation is identical to that in the last stage of the first extension of the model discussed in section 3.2.2 we already know what the informed individuals will do in this stage. The informed individuals will vote sincerely, i.e. according to their signal.[24] But what will the uninformed do? As also already argued in section 3.2.2 the uninformed individuals are indifferent between voting for either alternative, because voting for each yields an expected payoff of $\frac{1}{2}$. In section 3.1.2 we stated that individual i only votes for alternative A (B) if

$$E\left[U_i(A,s)\middle|Piv_i(\sigma^*_{-i}),t_i\right] > (<) E\left[U_i(B,s)\middle|Piv_i(\sigma^*_{-i}),t_i\right].$$

Because neither of these conditions is satisfied and the uninformed individual has the option of choosing abstention she will not vote at all. For the uninformed individual abstaining also

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[23] Although their model is one of costly participation, they argue that the cost of participation can be interpreted as the cost of purchasing, or observing, the signal (see Ghosal and Lockwood (2003, p. 5).

[24] This solution is also derived by Persico (2004, p. 174) who states that when majority rule is the statistically optimal rule all individuals willing to acquire information must all be voting sincerely afterwards. The same argument is used by Ghosal and Lockwood (2003, p.7)

constitutes a sincere strategy.[25] If she were not voting sincerely and instead randomised her vote, the outcome would be identical to that in the model's first extension in section 3.2.

We now turn to the first stage, where individuals decide whether or not to acquire information. Let p again denote the ex-ante probability that any individual i acquires information about the true state of the world at cost c. Thus, the probability that exactly k individuals other than i have chosen to acquire information is

$$v(k,p)=\binom{n-1}{k}p^k(1-p)^{n-1-k}.$$

In order to characterize individual i's equilibrium voting strategy we have to calculate her gain from acquiring information relative to not acquiring information. We already know that individuals will vote sincerely, i.e. only the k informed individuals will cast a vote either for proposal A or B depending on the information they actually receive. The $n-1-k$ uniformed individuals will abstain, so they do not influence the outcome of the voting process. So only the k informed individuals have to be considered in determining when individual i is pivotal.

Now we have to consider two possible cases: k being even and k being odd. In the first case (k is even), i is only pivotal when the k informed individuals generate a tie, i.e. that exactly $\frac{k}{2}$ of the informed individuals vote for alternative A and the other $\frac{k}{2}$ informed individuals vote for alternative B. Now, if individual i does not acquire information she abstains and does not vote for any alternative. The tie remains yielding an expected payoff of $\frac{1}{2}$, because the alternatives are selected randomly, both with probability $\frac{1}{2}$. If individual i acquires information, though, she can update her belief about the true state of the world with her own signal. As she is pivotal and all the other k informed individuals vote sincerely, individual i knows that $\frac{k}{2}$ of them has received signal a and the other $\frac{k}{2}$ have received signal b. Thus, the voting behaviour of the other informed individuals, and the underlying signals, conveys

[25] Persico (2004, p. 171) defines sincere voting as voting in accordance with one's signal. In that sense, this voting behaviour is sincere, because the uninformed individual does not receive a signal and thus cannot replicate it through her vote. As a result abstention is a sincere behaviour.

no additional information to individual i about the true state of the world, because the signals of the others cancel each other out. Having only her own signal to rely on, individual i votes sincerely, i.e. according to her signal, selecting the correct alternative with probability q.[26] So her gain from acquiring information relative to not is $q - \frac{1}{2}$.

Given that exactly k other individuals acquire information and k being even, the unconditional probability that $\frac{k}{2}$ individuals receive a signal in favour of each alternative is:[27]

$$w(k,q) = \binom{k}{\frac{k}{2}} q^{\frac{k}{2}} (1-q)^{\frac{k}{2}}.$$

In the second case (k is odd) individual i is only pivotal when $\frac{k-1}{2}$ of the other individuals vote for one alternative and $\frac{k+1}{2}$ individuals vote for the other alternative. In this case, when individual i acquires information, the signals underlying the other individuals' voting behaviour does convey information to i. There are two possibilities of the votes being distributed.

One possibility is that $\frac{k+1}{2}$ of the other individuals have voted in accordance with individual i's signal and $\frac{k-1}{2}$ have voted opposing to individual i's signal. Then, including i's own signal, there are $\frac{k+1}{2}+1$ signals in accordance with i's own signal and $\frac{k-1}{2}$ opposing it.

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[26] One could also apply the formula for the posterior probability $\beta(j,k)$ which we already used in section 3.2.2 to compute the gain from acquiring information. Only here, for each situation where k is even, and thus $j = \frac{k}{2}+1$, the gain from acquiring information is always the same, whereas in the model without abstention each situation individual i is pivotal in yields a different gain.

[27] It is sufficient to use the unconditional probability, because the exponents of both factors are the same and the accuracies of the signals, given the true state of the world, are the same as well: $P[a|A]^{\frac{k}{2}}(1-P[a|A])^{\frac{k}{2}} = P[b|B]^{\frac{k}{2}}(1-P[b|B])^{\frac{k}{2}} = q^{\frac{k}{2}}(1-q)^{\frac{k}{2}}$. We already used this relationship once in the analysis of section 3.1.2.

Therefore, individual i prefers the alternative her signal favours,[28] but she also knows that she does not need to acquire information and vote accordingly, because there already is a majority for this alternative and it would also be selected without her vote.

The other possibility is that $\frac{k-1}{2}$ of the other individuals have voted in accordance with individual i's signal and $\frac{k+1}{2}$ have voted opposing to individual i's signal. Including i own signal, there are now $\frac{k-1}{2}+1=\frac{k+1}{2}$ signals in accordance with i's and $\frac{k+1}{2}$ opposing it, i.e. there is an equal number of signals favouring each alternative. Therefore, individual i is indifferent between the two alternatives.[29] Because this is no improvement compared to her prior belief, individual i's gain from acquiring information is zero. Ghosal and Lockwood (2003, p. 8) call this a "weak swing voter's curse".

From the discussion above we can infer the unconditional gain from acquiring information as

$$B(p)=\left(q-\frac{1}{2}\right)\sum_{k=0}^{n-1}v(k:p)\gamma(k:q)$$

where

$$\gamma(k:q)=\begin{cases} w(k:q) & k \ \ even \\ 0 & k \ \ odd \end{cases}$$

An individual will only acquire information about the true state of world when the gain from acquiring that information $B(p)$ exceeds (or is at least equal to) the cost c. By setting $B(p)=c$ and solving for p we get the mixed strategy for any individual i acquiring information. Every informed individual will then vote according to her signal and the uninformed individuals will abstain: $\sigma_i=(p,p_a,p_b)=(p,1,1)$.

[28] Applying the formula for the posterior probability $\beta(j,k)$ yields a value larger than $\frac{1}{2}$ for the probability of the alternative that i's signal favours being the correct alternative.

[29] Applying the formula for the posterior probability $\beta(j,k)$ yields that each alternative is correct one with probability $\frac{1}{2}$.

From the discussion above we can now summarize the equilibrium behaviour of individual i: Each individual i acquires information (and receives a signal t_i with probability p. Each individual then votes sincerely, i.e. she votes for alternative A upon receiving signal a and for alternative B upon receiving signal b, and she abstains if she acquires no information.

Again, we can apply the paramenters to be used in the experiment to calculate the equilibrium probability of acquiring information for the group size $n = 3$. Setting the cost $c = 0.125$ and the probability of receiving the correct signal $q = 0.75$ the equilibrium probability of acquiring information is: $p = 0.32071$.

When abstention is possible the probability of the group making the correct decision is given by

$$P[correct] = \sum_{i=0}^{n} \sum_{k=\left\lfloor \frac{i+1}{2} \right\rfloor}^{i} \binom{n}{i} p^i (1-p)^{n-i} \binom{i}{k} q^k (1-q)^{i-k} \left(1 - \left(\frac{1}{2}\right) \cdot 0^{2k-i}\right).$$

For the case $n = 3$, $c = 0.125$ and $p = 0.6154$ this is 0.67484. Just like in the model without abstention, the group performs worse than any single individual would alone. In the next section we present a brief comparison of the two voting games with and without abstention which will serve as a basis for the analysis of the experimental data in section 5.

3.4 Comparing Compulsive and Voluntary Voting

To get an overview and make comparison easier, the values of the probability of individuals acquiring information, p, and the probability of the group being correct, given p, are summarized for different values of c in the following tables. The signal's accuracy q is always kept constant at 0.75.

$c = 0.125$	Condorcet	Compulsive		Voluntary	
	$P[correct]$	p	$P[correct]$	p	$P[correct]$
$n = 3$	0.84375	0.61538	0.62080	0.32071	0.67484
$n = 5$	0.89648	0.00000	0.50000	0.18077	0.66190

$n=7$	0.92944	0.00000	0.50000	0.12537	0.65652

Table 4: Comparison of group accuracy for the different models for $c = 0.125$

$c=0.1$	Condorcet	Compulsive		Voluntary	
	$P[correct]$	p	$P[correct]$	p	$P[correct]$
$n=3$	0.84375	0.94201	0.82274	0.42303	0.70817
$n=5$	0.89648	0.54853	0.74452	0.24709	0.69898
$n=7$	0.92944	0.00000	0.50000	0.17334	0.69405

Table 5: Comparison of group accuracy in the different model for $c = 0.1$

The probability of information acquisition decreases for both compulsive and voluntary voting when the group-size is increased. As already pointed out earlier (see section 3.2.2) this effect stems from the fact that in a larger group the probability of being pivotal declines, thus decreasing the gain from acquiring information. According to Persico (2004, p.166) this result is already predicted by common sense. The larger a committee becomes the less responsible the members become for the decision, as this is the usual argument to explain why the average voter is often poorly informed. Consequently the probability of the group making the right choice in both models declines as well. It is worth to point out that p declines much faster, reaching zero quite rapidly when abstention is not possible than when voting is voluntary. As a result when no one acquires information the group makes random selections with a 50% chance of making the correct decision. Still, when p is positive it is considerably larger than under voluntary voting. The reason for the sharp decline of p under compulsory voting is the fact that two different negative externalities influence the gain of acquiring information: the negative participation externality identified by Börgers (2004) and the negative informational externality induced by the uniformed voters.

In contrast, when increasing group-size under voluntary voting the probability of acquiring information p seems to converge to a certain value, given the cost c. From the few data listed in tables 4 and 5 it is already obvious that the lower limit for p is larger the lower the cost, which is intuitive.[30] There still exists a negative participation externality that decreases the chance of being pivotal. But because only informed individuals cast a vote and thus, as

[30] There may be a threshold group-size which causes p to decline to zero under voluntary voting as well. This still remains to be shown.

they vote sincerely, contribute a piece of information to the outcome, there is a counterbalancing positive informational externality (see Ghosal and Lockwood, 2003).

Ghosal and Lockwood (2003, pp. 11-16) show that in their costly voting model equilibrium participation is inefficient, i.e. too few voters participate. As their model can easily be reinterpreted as one of costly information acquisition with abstention, as we did in section 3.3.2, we can conclude that in our model the informed participation rate is too low as well. Ghosal and Lockwood (2003, p. 15) show that compulsory voting may be desirable. This is true for their model, because there information is exogenous, i.e. each individual is already informed. Given the comparison above, in our context compulsory voting is inferior to voluntary voting, especially for large electorates.[31] The group performance could in both cases be enhanced by lowering the cost of information and thus raising the probability of acquiring it.

It is worth mentioning once more the similarity of both our extensions to the result obtained by Mukhopadhaya (2003). In both cases, when abstention is allowed and when it is not allowed, smaller groups perform better in selecting the correct alternative. This makes our models more applicable to small groups like juries and committees. Mukhopadhaya 2003, p. 40) also presents an intriguing intuition which applies to our results as well. When the group is small the probability of acquiring information is high. But there is still not much information, because there are not many individuals who could become informed. When a group is large there are many individuals who could acquire information, but again, as the probability of information acquisition declines, still not much information can be aggregated.

In the following experiment we will examine if the identified externalities play a role in the actual behaviour of individuals and if so, to what extent.

4 Experimental Set-Up and Design

The experiment was conducted at the Cologne Laboratory for Economic Research at the University of Cologne. Most of the 220 participants were students of the University of Cologne, the most of which were undergraduate students of the Faculty of Economics,

[31] Bear in mind that our model is very simple and certainly deserves some further refinement to allow for any conclusion for real elections. But simple as it is, it certainly constitutes a good starting point for further analysis.

Business Administration and Social Sciences, which were recruited by the Online Recruitment System of the Cologne Laboratory for Economic Research, which is an internet platform that can be accessed by anoyone interested in participating in experiments. The experiment was programmed and conducted with the software Z-tree (Fischbacher 1999). Z-tree is a modular C++-based language, which allows participants to interact with each other on a local area network (LAN).

During the experiment the participants were to earn points on the basis of their decisions which were exchanged into Euro after the experiment: 800 points were worth 1 Euro, i.e. the exact exchange rate in terms of Euro was 0.00125 Euro/point. Irrespective of their earned points, each participant received a show-up fee of 2.50 Euro. Both the show-up fee as well as the exchange rate were known to all participants from the start of the experiment. The final payoffs ranged from 8.40 Euro to 14.8 Euro (including the show-up fee) with an average payoff of 11.83 Euro.

4.1 Experimental Design

As this is, to our knowledge, the first experiment addressing the effects of compulsory and voluntary voting on the information acquisition behaviour in voting games, there exists no design we could refer to as benchmark. We tried to fit the model as accurately and as simply into an expiremtal environment in order to test for the theoretical predictions of the model.

The experiment consisted of eight sessions: four sessions with 27 participants each with groups of three individuals, and four session with 28 participants each with groups of seven individuals. Each session consisted of two treatments with the treatment variable being the voting institution: One treatment was the voting game with costly private information where abstention *was allowed* which will further be referred to as the “voluntary” treatment; the other treatment was the voting game with costly private information where abstention *was not allowed* which will further be referred to as the “compulsive” treatment. Both of these treatments were played for 30 rounds during each session. For each group size, in two of the four sessions the voluntary treatment was conducted first, followed by the compulsive treatment. In the other sessions the order of the treatments was reversed. Table 6 summarizes the experimental design.

	Group size n	Order of treatments		# of Matching groups	# of participants
Session 1	3	Voluntary	Compulsive	3	27
Session 2	3	Compulsory	Voluntary	3	27
Session 3	7	Voluntary	Compulsive	3	28
Session 4	7	Voluntary	Compulsive	3	28
Session 5	7	Compulsive	Voluntary	2	28
Session 6	7	Compulsive	Voluntary	2	28
Session 7	3	Voluntary	Compulsive	2	27
Session 8	3	Compulsive	Voluntary	2	27

Table 6: Experimental design

The technique of letting the same sample of subjects play different treatments one after another is called a 'within subjects' design (see Friedman and Sunder, 1994, p. 25),[32] because the experimenter examines the different effects different treatments have on the same subjects.[33] This particular design has the advantage that the experimenter can examine if different treatments have different effects on the behaviour of same participants.[34] A disadvantage of this design is the possibility of order effects. When conducting two (or more) treatments after another, the results of these treatments are interdependent and may correlate in some way. The results of the first treatment may influence the participants' behaviour in the second treatment. Such effects, e.g. practice, fatigue or boredom, are called order effects. This is why the order of treatments was reversed in the second session. With this technique, known as counterbalancing or balanced switchover (see Friedman and Sunder, 1994, p. 30), we can check for any order effects after the experiment by comparing the behaviour of the two groups for each treatment.[35]

In each session the participants were divided into matching groups. In the the session with group-size n=3 there were 3 matching groups consisting of 9 participants each, while in the sessions with group-size n=7 there were 2 matching groups consisting of 14 participants each. Those matching groups were kept unchanged during the whole session, i.e. they were neither

[32] Sometimes this is also called a 'repeated measures' design, because the participants are repeatedly exposed to different treatments.

[33] Opposing to this is a 'between subjects' design. In a 'between subjects' (sometimes called independent measures design) each treatment is played by totally different groups of subjects.

[34] This advantage exists in comparison to the independent measures design (see footnote 31). There significant differences may be observed between the behaviour of the groups which are not the result of the treatments, but rather of individual differences between the groups of participants (see Siegel and Castellan, 1988, p. 73).

[35] Order effects can be precluded if the groups from both session behaved equally (or at least similarly) in a particular treatment, regardless which order the treatments were played in.

chnaged during the course of a treatment nor during the transition from the first to the second treatment. At the beginning of each of the 30 rounds played in each treatment, the subjects within a matching group were randomly divided (matched) into groups of the session specific group-size. This is called a ‘strangers’ design, because in every round an arbitrary participant will play with different group members. Of course, with a matching group of 9 subjects and playing for 30 rounds, it cannot be guaranteed that a participant always plays with somebody different. Eventually she has to meet the same persons again, although because of the anonymity of the participants she may never know when that occurs. This particular design is a ‘quasi-stranger’ design.[36] We chose this design because with a group-size of three were are looking at small electorates, such as committees of experts. Those committees do never consist of the same persons as the issue to decide on changes every time the committee is convened, so each time different experts are summoned. As we use a ‘quasi-strangers’ design the decisions of all subjects being randomly matched are interdependent in some way. As a result we obtain only one single observation from these individuals. This is a reason why we divided all 27 participants of a session into three matching groups. Because we are only randomly matching within those matching groups, we obtain three independent observation. Taken both sessions together, we thus have six independent observations for the whole experiment.

4.2 Parameter Setting and Predictions

In order to fit our models into an experimental environment, we adjust the model’s parameters as to make it as easy as possible for the participants to comprehend. From the description of the experimental design in section 4.1 it is already clear that we have chosen group-sizes $n = 3$ and $n = 7$.

The states of world are represented by colours: “yellow” and “blue”. The colours were carefully chosen, so they could not be linked to any context, such as political parties, that could bias the choice of the participants.[37] The information the participants could acquire were colours as well, showing the correct colour with a probability of 75%. Moreover, we chose the following parameter setting, which was identical for all treatments:

[36] In a ‘total stranger’ design every subject would meet any other subject only once during the whole experiment.
[37] It was unavoidable that “yellow” or “blue” would be the favourite colour of some participants. From the questionnaire could be gathered that one participant used his favourite colour as a focal point and chose it more often than the other.

Parameter	Value	In points
Payoff for choosing the correct alternative (correct colour)	1	200
Payoff for choosing the wrong alternative (not the correct colour)	0	0
Signal cost c	0.125	25
Signal accuracy q	0.75	-

Table 7: Parameter setting

Using those parameters, as an example we can draw the function $B(p)$ for for $n = 3$ for both the voluntary and der compulsive treatment as shown in figure 1. Additionally, the cost have been plotted as well, so it can readily bee seen where the individuals' theoretical mixed strategies for each treatment are located: at the intersections of the respective function $B(p)$ and the cost.

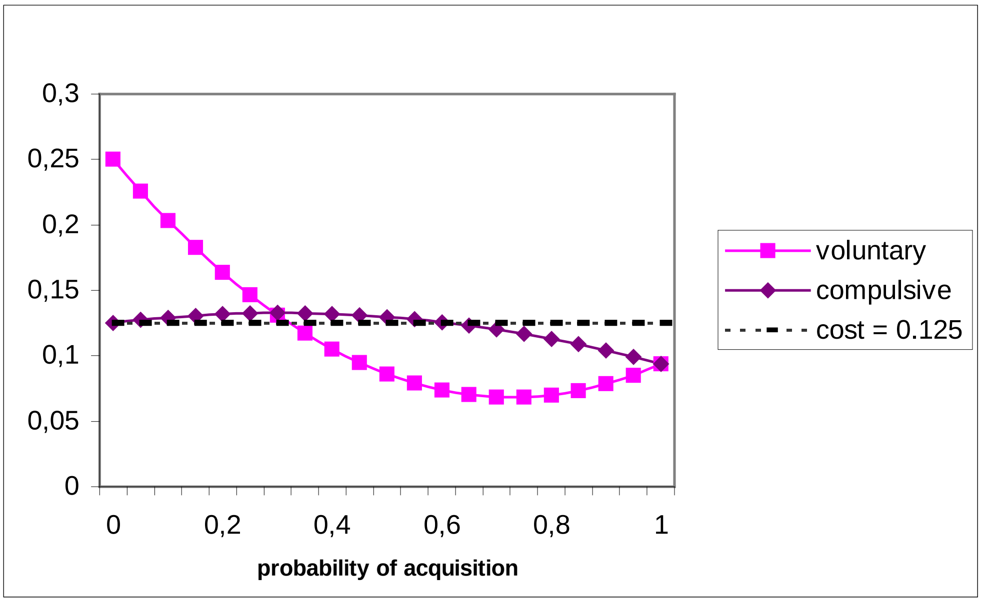

Fig. 1: Gain from information acquisition in different treatments for group-size n=3

As we already have calculated the theoretical values for the equilibrium probability of information acquisition, we just summarize them here: Individuals in small groups ($n = 3$) will acquire information with probability 0.6154 when in the voluntary treatment and with probability 0.3207 in the compulsory treatment. The probabilities for large groups ($n = 7$) are 0.125 and 0, respectively.

4.3 Running the Experiment

At the beginning of the experiment, the participants each drew a number which assigned them to a computer terminal: The computer terminals were situated in cubicles, so that the participants were separated from one another and could neither communicate with each other nor peek at anyone else's computer monitor to see what they were doing. Every participant found at her place written instructions, which she was asked to read carefully,[38] as well as pen and paper to make notes during the experiment. Remaining questions were answered privately. To assure that everyone understood the instructions, a short quiz was handed out to every participant. After having answered all the questions in the quiz, the participants had to raise their hand, so that one of the experimenters could check if they were answered correctly and clear any remaining obscurities privately. After concluding the first treatment, there was a short break, the participants were shown a summary of their performance so far and were handed out the instructions for the second treatment which explained what would change compared to the first treatment. Another quiz was handed out as well to assure everyone understood the changes. Again, it was checked immediately by one of the experimenters and remaining questions were cleared privately.

Each of the 30 periods within a treatment had the same principle set-up. After the computer had matched the participants of every matching group into groups, it randomly determined a colour (yellow or blue) as the "correct" colour for each of the resulting groups which the participants were not informed about, though. The "correct" colour represents the true state of the world in our model. The probability of every colour being the "correct" colour was the same, i.e. 50 percent. On the first screen,[39] then the participants were asked if they wanted to acquire information about the "correct" colour at a cost of 25 points which was subtracted from their score.[40] The participants knew that if they acquired information, it would only represent the "correct" colour with a probability of 75 percent; with a probability of 25 percent it would show the opposite of the "correct" colour. The acquired information was of course dependent on the "correct" colour of the group the participant was a member of for this

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[38] A translation of the instructions which were originally written in German can be found in the appendix.
[39] Refer to the instructions in the appendix to get an impression of the appearance of the screens.
[40] When a group selects the "correct" colour, each member earns 200 points. Hence, the cost of 25 points for acquiring information corresponds to the parameter setting $c = 0.125$, because $0.125 \cdot 200 = 25$.

round, but was independent of the information the other members of the same group did (or did not) acquire.

After having decided whether to acquire information or not, the second screen appeared. Those participants who acquired information were shown the colour of their information. Now, each participant, whether she acquired information or not, was asked to choose which of the two colours (yellow or blue) was the “correct” colour for her group in this round. In the voluntary treatment, the participants could choose between yellow, blue and choosing no colour, i.e. abstaining. In the compulsory treatment, they could only choose between yellow and blue. This was the only difference between the two treatments.

After having made their choice, the computer determined the majority decision made by each group. For each group the number of participants choosing yellow and blue were added up, respectively. The colour with the higher count determined the majority decision. In case of a tie, which could only occur in the voluntary treatment, the majority decision was randomly determined by the computer (with each colour having a probability of being the majority decision of 50 percent). The participants were shown the result screen, which concluded every period. This screen contained the following data: whether or not a participant had acquired information and which colour it showed, the colour the participant chose (if she chose any), the number participants in her group choosing yellow and blue, respectively, the group decision arrived at through majority rule, the “correct” colour, the points earned in this round, and the new score.

At the end of the experiment, the participants were asked to fill in a brief questionnaire. They were asked to explain their pattern of behaviour, if they had any, if (and why) they changed it during the second treatment, and if they prfered any treatment over the other. Furthermore, they were asked if they had any basic knowledge of game theory, if they were satisfied with their particular results (meaning their payoff), and if they had fun participating.

5 Analysis of the Results

5.1 Information Acquisition

The first question we would want to answer is whether the obtained data support the theoretical predictions of the models derived in section 3. In order to check for the correctness of these predictions, the aggregated frequency of information acquisition for every matching group and treatment was calculated from the data. Because by choosing a repeated measures design we checked for order effects, we can aggregate all voluntary and compulsive treatments and thus, for each treatment, obtain 12 observations for the group-size of 3 and 8 observations for the group-size of 7. For each group-size and treatment, applying a Wilcoxon-Mann-Whitney Test, the null hypothesis of no difference between the same treatment conducted first and sceond cannot be rejected, which statistically supports the absence of order effects.[41] Tables 8 and 9 give an extended overview of the average frequencies of the single matching groups for the group-sizes of 3 and 7, respectively. Besides the overall average frequencies of each treatment, the average frequencies in the first and last period of each treatment as well as the average frequencies of both halfs of each treatment are given.

N=3	**voluntary**					**compulsive**				
	average	first period	last period	first half	second half	average	first period	last period	first half	second half
Session 1										
matching group 1	0,500	0,556	0,444	0,541	0,459	0,778	0,667	0,889	0,785	0,770
matching group 2	0,359	0,556	0,222	0,400	0,319	0,481	0,556	0,556	0,467	0,496
matching group 3	0,267	0,333	0,111	0,252	0,281	0,385	0,444	0,333	0,459	0,311
Session 2										
matching group 1	0,411	0,444	0,556	0,437	0,385	0,544	0,556	0,556	0,563	0,526
matching group 2	0,274	0,444	0,111	0,326	0,222	0,356	0,222	0,222	0,319	0,393
matching group 3	0,322	0,333	0,444	0,326	0,319	0,289	0,667	0,111	0,370	0,207
Session 7										
matching group 1	0,330	0,333	0,333	0,319	0,341	0,370	0,444	0,333	0,407	0,333
matching group 2	0,552	0,556	0,556	0,578	0,526	0,859	1,000	0,778	0,874	0,844
matching group 3	0,581	0,556	0,667	0,511	0,652	0,681	0,778	0,778	0,719	0,644
Session 8										
matching group 1	0,200	0,222	0,222	0,267	0,133	0,348	0,444	0,333	0,356	0,341
matching group 2	0,174	0,444	0,222	0,178	0,170	0,311	0,333	0,111	0,378	0,244
matching group 3	0,219	0,333	0,222	0,237	0,200	0,196	0,222	0,222	0,207	0,185
average	0,349	0,426	0,343	0,364	0,334	0,467	0,528	0,435	0,492	0,441
std. deviation	*0,137*	*0,114*	*0,186*	*0,129*	*0,153*	*0,208*	*0,228*	*0,270*	*0,203*	*0,218*
theoretical prediction	0,321					0,615				

Table 8: Summary of average frequencies for group-size of 3

voluntary					compulsive				
average	first period	last period	first half	second half	average	first period	last period	first half	second half

[41] For the group-size of 3, however, this null hypothesis had to be rejected if one chose a significance level of 0.01.

Session 3										
matching group 1	0,260	0,429	0,357	0,276	0,243	0,340	0,571	0,214	0,390	0,290
matching group 2	0,219	0,286	0,214	0,257	0,181	0,367	0,429	0,357	0,371	0,362
Session 4										
matching group 1	0,271	0,357	0,214	0,300	0,243	0,460	0,500	0,357	0,467	0,452
matching group 2	0,329	0,571	0,214	0,343	0,314	0,381	0,714	0,214	0,467	0,295
Session 5										
matching group 1	0,243	0,214	0,214	0,238	0,248	0,379	0,286	0,429	0,343	0,414
matching group 2	0,288	0,214	0,143	0,300	0,276	0,376	0,357	0,286	0,405	0,348
Session 6										
matching group 1	0,281	0,500	0,286	0,314	0,248	0,374	0,786	0,357	0,448	0,300
matching group 2	0,279	0,357	0,143	0,290	0,267	0,376	0,429	0,357	0,438	0,314
average	0,271	0,366	0,223	0,290	0,252	0,382	0,509	0,321	0,416	0,347
std. Deviation	*0,032*	*0,129*	*0,071*	*0,033*	*0,038*	*0,034*	*0,173*	*0,076*	*0,046*	*0,060*
theoretical prediction	0,125					0,000				

Table 9: Summary of average frequencies for group-size of 7

For a group-size of 3 theory predicted that individuals gather information with a lower probability when abstention is allowed than when abstention is not possible. In figure 3, the average aggregated relative frequencies of information acquisition of all matching groups with n=3 are displayed for each treatment. It is easy to see that the frequencies in the compulsive treatment always stay above the frequencies in the voluntary treatment. The experimental data confirm this qualitative prediction in that the overall average frequency of information acquisition in the voluntary treatment is significantly lower than in the compulsive treatment (Wilcoxon Signed Rank Test, two-tailed, $p<0.01$, N=12). Comparing the predicted probabilities with the observed frequencies shows that quantitatively the theoretical predictions are not very accurate.

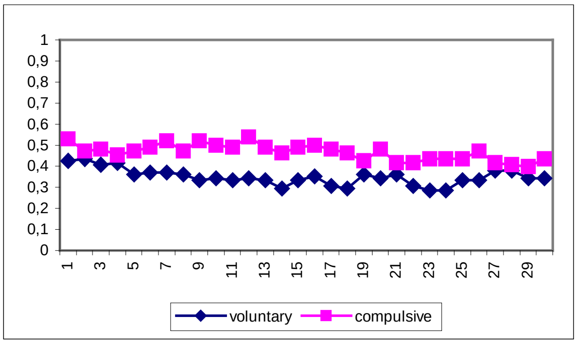

Fig. 3: Average relative frequency of information acquisition for group-size n=3

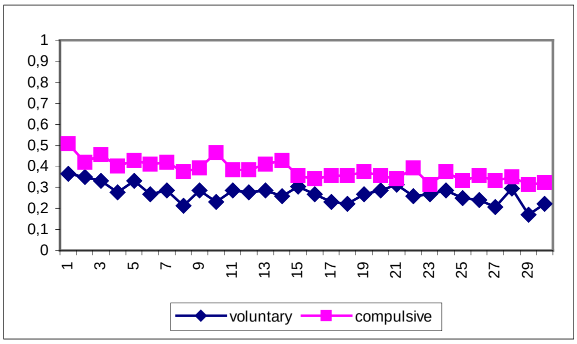

Fig. 4: Average relative frequency of information acquisition for group-size n=7

Figure 4 shows the average aggregated frequencies of information acquisition for all matching groups with n=7. As with the smaller groups, here the frequencies in the voluntary treatment are also always lower than the frequencies in the compulsory treatment (Wilcoxon Signed Rank Test, two-tailed, p<0.01, N=8). This totally contradicts theory which predicted the opposite. Moreover, theory predicted that in the compulsive treatment indiviuals in groups of 7 would not acquire information at all. So here, theory is neither quantitavely nor qualitatively correct. Obviously, being forced to vote triggers some sense of responsibility for the group, so that some individuals invest in information despite the chance of being pivotal being quite small.

In order to gain more insights on the individuals' behaviour and to test another theoretical prediction, we also compare for both the voluntary and compulsive treatment if a change in group-size also changes information acquistion behaviour. Figures 5 and 6 show the frequencies of information acquisition of both group-sizes for the voluntary and compulsive treatment, respectively. The theoretical prediction was that, in each treatment, larger groups acquire information with a lower probability.

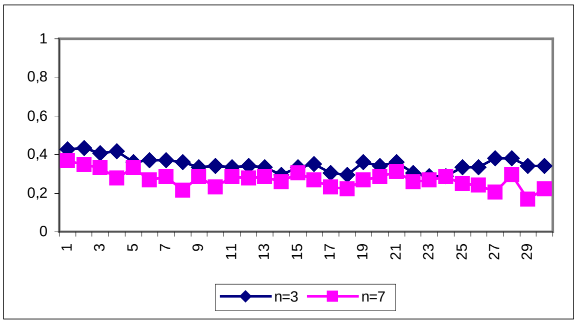

Fig. 5: Average relative frequency of information acquisition for the voluntary treatment

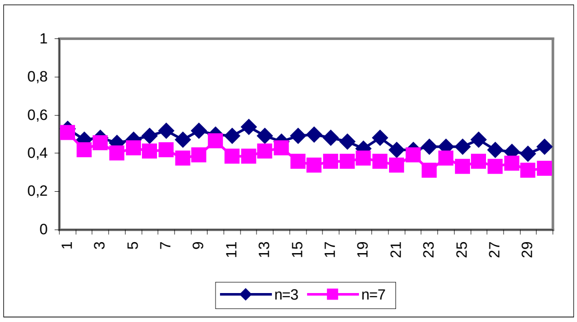

Fig. 6: Average relative frequency of information acquisition for the compulsive treatment

The figures show that for both the voluntary and the compulsive treatment the frequencies of information acquisition of smaller groups always stay above those of larger groups. When the group-size is increased the subjects may feel less responsible for the group decision, as has been suggested Mukhopadhaya (2003), where increasing group size reduces the incentives of becoming informed. From the experimental results we may conjecture that the participants seem to realize this opportunity of more easily free riding on others' information when groups are larger. The difference between these frequencies is not statistically significant, though.

From the answers the participants gave in the questionnaire we can gather that approximately half of them realized that acquiring information and voting accordingly would result in a larger probability of choosing the correct colour. But at the same time most of them argued that the other members of their group must realize the benefit from acquiring information, too, so they would not have to invest in information themselves. Obviously, despite the cost being quite low (12.5% of the gain in the case of a correct group decision) many participants were reluctant to spent points for a signal. Many participants say that they wanted to keep their cost low, i.e. spending as little points as possible. Only a few participants mentioned that the cost was, in their opinion, very low in the face of the possible gain so they ignored them totally and always acquired information. The participants realizing the benefit of acquiring information, although not always buying some, also expressed that it was more important to acquire information in the non-abstention treatment, because they were afraid to push the group decision in the wrong direction by just guessing a colour. The risk of free riding was too high when abstention was not possible. Furthermore, some participants even expressed that they understood investing in information as a duty of increasing the welfare of the group, and did so in both treatments, which supports the ethical voter odel of Feddersn and Sandroni (2004).[42]

Another portion of the participants interpreted the experiment as a game of chance and in both treatments guessed a colour most of the time without acquiring information. Most of them mentioned in their answers that they were acting “intuitively” or described their own method of choosing which colour to vote for.[43] Some even picked a colour in advance and always chose that colour.[44] Others claim that they received a “wrong” signal too often and thus did not see why they should invest in poor information. Also, some of the “guessing” participants wrote in the questionnaire that they were trying to find out the “real” probabilities of each colour by observing the frequencies of them being the correct colour. Obviously they did not trust that the computer would determine the colour with the probabilities given in the instructions, nor did they trust the accuracy of the information.

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[42] Riker and Ordeshook (1968) first introduced a voting model which considered political satisfaction playing an important role in explaining why people vote despite the fact that they seldom are pivotal. It could be argued that it also triggers the acquisition of information despite the fact that no one else does.

[43] One participant explains her method of choosing the colour like this: She assigned the colours, and even the choice “no colour”, to certain one-digit numbers. Then she looked at documents she had on her during the experiment and used the digits of ID-numbers to make her choice. (For the original description of this method, refer to the transcript of the questionnaire in the appendix.)

[44] One participant used this method, but sometimes still acquired information just to ignore it at the same time.

One other thing could often be found in the answers of the participants. They often lament about declining cooperation, i.e. they claim that they had the feeling that other members of their group did not cooperate in also acquiring information, so they gave up getting informed as well, as they did not see why they should be the only ones investing in information. We examine this hypothesis by comparing for each treatment separately the average relative frequency of information acquisition of the first half of the session (periods 1-15) with the average of the second half of the experiment (periods 16-30) as already given in table ???. Applying a Wilcoxon Signed Rank Test we can reject the null hypothesis of the relative frequency of the first half being smaller than the relative frequency of the second half ($p<0.05$; $N=12$) for groups of 3 individuals in the compulsive treatment. The same null hypothesis cannot be rejected for the same group-size in the voluntary treatment, though. When groups consist of 7 individuals, this null hypothesis can be rejected for both the voluntary and the compulsive treatment ($p<0.05$, $N=8$). One explanation for this could be that while becoming informed in small groups when abstention is possible, the acquired information is still useful although others do not acquire information simply because the uninformed can abstain and thus do not dilute the voting result by guessing. When abstaining is not possible the uninformed individuals' guesses may overcompensate the the value of the informed votes. So the individuals who initially become informed more easily deviate from their strategy as the their investment in information deflagrates. When the group-size is large a single information is worth less per sé, so that individuals more easily tend to quit acquiring information when they believe to observe declining information acquisition rates.

We can conclude that, indeed, compulsive and voluntary voting in our context and parameter setting give different incentives to gather information about the true state of world, such as political issues, party programs, etc. In contradiction to the theoretical predictions these incentives seem to stay the same irrespective the group-size. When individuals have the chance to abstain, they restrain more easily from investing in information and exploit this option to free ride on the information the other individuals in the electorate gather, without having to pay for information themselves. The higher frequency of information acquisition in the compulsory treatment may result from the fact that individuals develop a responsibility for the group, i.e. they are not willing to free ride on the other's information for the prize of pushing the group decision in a wrong direction due to one's own lack of information. Furhtermore, in larger groups the frequencies of information acquisition are c.p. larger than in smaller groups as the chance of being pivotal and the value of a single information decreases.

5.2 Sincere voting

We now turn to examining if individuals really vote sincerely, i.e. if they vote according to their signal. Recalling the relative frequency of information acquisition of the compulsive treatment (an overall average of 0.467 with groups of 3 and 0.382 with groups of 7), one can expect in advance that the number of sincere voters in that treatment cannot on average be larger than that frequency, because the uninformed voters do not have the chance of voting sincerely. As a matter of fact, in the compulsive treatment the frequencies of information acquisition and the frequencies of sincere voters are nearly identical, indicating that only very few informed individuals in acquire information and vote in opposition of the received signal.

It makes more sense to look at the informed and uninformed individuals separately, where the examination of the sincerity of the uninformed voters only makes sense in the abstention treatment. The informed voters in both treatments and with both group-sizes nearly always voted according to their signal and only very rarely chose to vote for the opposite of the signal they received. Mostly, as can be gathered from the answers in the questionnaire, because participants wanted to try things out. This is supported by the fact that most deviations from the signal take place during the first periods of a session. Aside from that, in the voluntary treatment, no informed participant ever chose not to use her information and abstain. This information can also be drawn from the answers in the questionnaire, because all participants who wrote that they acquired information also mentioned that they were voting accordingly. Some even stated that it wouldn’t make sense to vote for the other colour or, in the abstention treatment, abstain.

Applying a Wilcoxon Signed Rank Test the null null hypothesis of no difference in informed subjects voting sincerely between the treatments cannot be rejected for either group-size. Neither can the null hypothesis of no difference between the group-sizes for each treatment (Wilcoxon-Mann-Whitney Test), which leads to the conclusion that informed voters behave equally in each treatment and group-size.

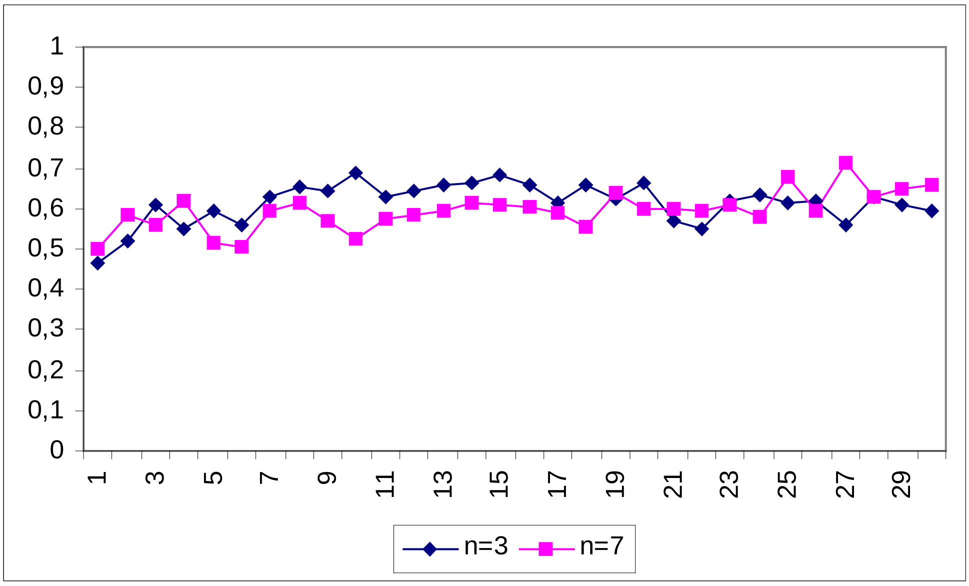

Fig. 7: Average relative frequency of uninformed sincere voters in the compulsory treatment

Now we take a look at the uninformed subjects in the voluntary treatment. Figure 6 shows the average relative frequencies of those subjects for both small and large groups. Applying a Wilcoxon-Mann-Whitney Test we cannot reject the null hypothesis of no difference between the uninformed individuals voting sincerely between the both group-sizes. When looking at figure 6, an increase in the relative frequencies of uninformed subjects voting sincerely over time can be observed. While an increase in this frequency is not statistically significant for small groups, it is highly significant for large groups (Wilcoxon Signed Rank Test, one-tailed, $p<0.01$, $N=8$). The comparatively low frequency during the first few periods may result form individuals experimenting with the possibilites of the treatment. It can be suspected that over time the subjects recognize the negative informational externality they cause by voting without having any information about the correct colour. And the fact that in small groups the level of uninformed sincere voters is maintained over nearly the whole course of the treatment suggests that individuals learn quicker about externality than in large groups, where the frequency rises over time.

5.3 Correctness

Does the voting institution and the group size have any influence on the overall average correctness of the group? Table 10 briefly summarizes the overall aggregate frequencies of groups choosing the correct colour. Comparing the frequencies to the theoretical predictions, we find that in the voluntary treatment the rate of being correct is lower (for small groups) or near (for large groups) the predicted value. In the compulsive treatment for both group-sizes the rate of a group being correct is way above the predicted value. The most peculiar thing about the results for small groups is that the numbers are nearly equal to the statistically calculated predictions, but they are exchanged. Furthermore, the frequency of being correct is higher under compulsive voting irrespective the group-size, although only the difference is only statistically significant for small groups (Wilcoxon Signed Rank Test, two-tailed, $p<0.05$, N=12). Small groups performing so well under compulsive voting despite the fact that they by far do not reach the predicted rate of information acquisition is quite surprising and once more supports Mukhopadhaya (2003) who states that small groups perform better than large ones.

	voluntary	compulsive
n=3	0,620	0,688
prediction	*0,675*	*0,615*
n=7	0,660	0,690
prediction	*0,657*	*0,500*

Table 10: Aggregate relative frequencies of the group being correct

6 Conclusion

As the conducted experiment is the first one testing the behaviour of subjects in a voting environment where private information is costly, we have no benchmark which we could compare our results to. The observed effects of the treatment variable concerning the voting institution on the probability of information acquisition were quite clear and statistically significant.. Irrespective of groupsize, the subjects gathered more information in the non-abstention treatment as they did not want to be responsible for any false group decision. In the face of that pressure they acquired information more often, even though the probability derived in the theoretical model was not perfectly reflected by the experimental data. Furthermore, individuals c.p. acquire less information when the group size is increased, because then the subjects feel less responsible for the group decision, as has been suggested Mukhopadhaya (2003), where increasing group size reduces the incentives of becoming informed. However, these results partially contradict the predictions by the theoretical model which calls for a further refinement of the model. The experiment also showed, that when subjects acquire information they use it by voting accordingly. But it also showed that uninformed voters, even when they have the chance of abstaining and not influencing the outcome of the group decision directly, still tend to cast a vote randomly, thus not voting strategically and ignoring the negative externality this behaviour has on the group.

So is compulsory voting really a preferrable option? Theory predicted that many individuals stay uninformed. A political argument for compulsory voting is to assure that little majorities should not be getting to much influence on the election outcome (such as interest groups etc.). Our model predicts that mandatory voting in large electorates has a negative influence on the information acquisition behaviour and thus on the performance of the group. Our experimental results show that this not true, at least not to the dramatic extent suggested by theory. But although compulsive voting was able to set an incentive to gather more information even in large groups, large groups could not quite outperform small ones.

A possible flaw in the model as well as in the experiment is not to allow for an even number of individuals in a group. If an even number of group members were allowed, also in the compulsory treatment a tie could occur which would have to be resolved by a fair coin toss. In the experiment the computer would determine the majority decision. This would make the two treatments more comparable, because, as stated by many participants in the questionnaire, they had a problem with the random decision mechanism used in only one treatment, thus evaluating it as more diffcult which made them tending to behave more like participating in a guessing game where everything was dependent on chance and could not be influenced whatsoever.

A interesting extension to our experiment could be introducing an endogenous choice between the two voting institutions, where in an initial period the group may choose if they rather would like vote in a voluntary or a compulsory environment. This way, one could examine two aspects: first, if the preference for either of the institutions influences the behaviour in the actual voting situation, and second, if merely the possibility to choose has any effect on the individuals' behaviour. These questions should be answered in further experiments.

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Appendix A

Equilibrium Derivations for the Basic Model

The equilibrium conditions for the pure strategy equilibrium are $w(a) > 0$ and $w(b) < 0$. Inserting $p_a = 1$ and $p_b = 1$ into $P[Piv_i(\sigma^*_{-i})|s]$, all the summands where $j \neq k$ and $j \neq \frac{n-1}{2}$ are zero it reduces to

$$P[Piv_i(\sigma^*_{-i})|s] = \binom{n-1}{\frac{n-1}{2}} P[a|s]^{\frac{n-1}{2}} (1 - P[a|s])^{\frac{n-1}{2}}.$$

Now, there is only one case left which individual i is pivotal in, that is when one half of the other individuals receive signal a and the other half of the others receive signal b. Because the exponents of both factors are the same and the accuracy of the signal, dependent on the true state, is the same for both states, we can further simplify the term and obtain the unconditional probability of being pivotal:[45]

$$P[Piv_i(\sigma^*_{-i})] = \binom{n-1}{\frac{n-1}{2}} q^{\frac{n-1}{2}} (1-q)^{\frac{n-1}{2}}.$$

The condition $w(a) > 0$ leads to

$$w(a) = \frac{1}{2} q \binom{n-1}{\frac{n-1}{2}} q^{\frac{n-1}{2}} (1-q)^{\frac{n-1}{2}} - \frac{1}{2}(1-q) \binom{n-1}{\frac{n-1}{2}} (1-q)^{\frac{n-1}{2}} q^{\frac{n-1}{2}} > 0$$

$$\Leftrightarrow \binom{n-1}{\frac{n-1}{2}} q^{\frac{n-1}{2}} (1-q)^{\frac{n-1}{2}} \left(\frac{1}{2} q - \frac{1}{2}(1-q) \right) > 0$$

$$\Leftrightarrow \frac{1}{2} q - \frac{1}{2} + \frac{1}{2} q > 0$$

[45] The relationship $P[a|A]^{\frac{k}{2}} (1 - P[a|A])^{\frac{k}{2}} = P[b|B]^{\frac{k}{2}} (1 - P[b|B])^{\frac{k}{2}} = q^{\frac{k}{2}} (1-q)^{\frac{k}{2}}$ shows that when the exponents are equal, the probability no longer depends on the true state of the world.

$$\Leftrightarrow q-\frac{1}{2}>0,$$

which is always satisfied as it represesnts our model's assumption about the value of q. The condition $w(b)<0$ leads to

$$w(b)=\frac{1}{2}(1-q)\binom{n-1}{\frac{n-1}{2}}q^{\frac{n-1}{2}}(1-q)^{\frac{n-1}{2}}-\frac{1}{2}q\binom{n-1}{\frac{n-1}{2}}(1-q)^{\frac{n-1}{2}}q^{\frac{n-1}{2}}<0$$

$$\Leftrightarrow\binom{n-1}{\frac{n-1}{2}}q^{\frac{n-1}{2}}(1-q)^{\frac{n-1}{2}}\left(\frac{1}{2}(1-q)-\frac{1}{2}q\right)<0$$

$$\Leftrightarrow\frac{1}{2}-\frac{1}{2}q-\frac{1}{2}q<0$$

$$\Leftrightarrow\frac{1}{2}-q<0$$

which is also always satisfied as it is another way of expressing $q-\frac{1}{2}\geq 0$, which again represents the model's assumption about q.

The condition for the hybrid equilibrium $p_a=1$ and $0<p_b<1$ are $w(a)>0$ and $w(b)=0$. Inserting $p_a=1$ into $P[Piv_i(\sigma^*_{-i})|s]$, all summands with $k\neq j$ are zero, resulting in

$$P[Piv_i(\sigma^*_{-i})|s]=\sum_{k=0}^{\frac{n-1}{2}}\binom{n-1}{k}P[a|s]^k(1-P[a|s])^{n-1-k}\binom{n-1-k}{\frac{n-1}{2}-k}(1-p_b)^{\frac{n-1}{2}-k}p_b^{\frac{n-1}{2}}$$

Since, as mentioned above, in equilibrium $w(a)>w(b)$, we only have to examine the condition $w(b)=0$.

$$w(b)=\frac{1}{2}(1-q)\sum_{k=0}^{\frac{n-1}{2}}\binom{n-1}{k}q^k(1-q)^{n-1-k}\binom{n-1-k}{\frac{n-1}{2}-k}(1-p_b)^{\frac{n-1}{2}-k}p_b^{\frac{n-1}{2}}$$

$$-\frac{1}{2}q\sum_{k=0}^{\frac{n-1}{2}}\binom{n-1}{k}(1-q)^{k}q^{n-1-k}\binom{n-1-k}{\frac{n-1}{2}-k}(1-p_b)^{\frac{n-1}{2}-k}p_b^{\frac{n-1}{2}}$$

$$=\sum_{k=0}^{\frac{n-1}{2}}\binom{n-1}{k}\left[\frac{1}{2}q^{k}(1-q)^{n-k}-\frac{1}{2}(1-q)^{k}q^{n-k}\right]$$

$$\times\binom{n-1-k}{\frac{n-1}{2}-k}(1-p_b)^{\frac{n-1}{2}-k}p_b^{\frac{n-1}{2}}\stackrel{!}{=}0$$

Because of $0<p_b<1$ the product at the end of the term cannot be zero, neither can the binomial coefficients. So, in order for $w(b)$ being zero the term in brackets has to be zero:

$$\frac{1}{2}q^{k}(1-q)^{n-k}-\frac{1}{2}(1-q)^{k}q^{n-k}\stackrel{!}{=}0\Leftrightarrow q=\frac{1}{2}$$

This condition can never be satisfied, because our model's assumption for the value of q is $\frac{1}{2}<q\leq 1$. Hence, $p_a=1$ and $0<p_b<1$ does not constitute an equilibrium in our model. An analogous line of argument shows that $p_b=1$ and $0<p_a<1$ is no equilibrium either. Thus, there exists no hybrid equilibrium in our model.

Appendix B

Example Calculation: Compulsory Voting for n=3

We now present an example calculation of the equilibrium probability of acquiring information for the group size $n=3$. First, we need to compute the gain from acquiring information relative to not:

$$B(p)=\binom{2}{0}p^{0}(1-p)^{2}\binom{0}{0}q^{0}(1-q)^{0}\binom{2}{1}\left(\frac{1}{2}\right)^{2}\left(\beta(1,1)-\frac{1}{2}\right)$$

$$+\binom{2}{1}p^{1}(1-p)^{1}\binom{1}{0}q^{0}(1-q)^{1}\binom{1}{1}\left(\frac{1}{2}\right)^{1}\left(\beta(1,2)-\frac{1}{2}\right)$$

$$+\binom{2}{1}p^{1}(1-p)^{1}\binom{1}{1}q^{1}(1-q)^{0}\binom{1}{0}\left(\frac{1}{2}\right)^{1}\left(\beta(2,2)-\frac{1}{2}\right)$$

$$+\binom{2}{2}p^2(1-p)^0\binom{2}{1}q^1(1-q)^1\binom{0}{0}\left(\frac{1}{2}\right)^0\left(\beta(2,3)-\frac{1}{2}\right)$$

$$=\left(q-\frac{1}{2}\right)\left[p^2\left(\frac{1}{2}-\frac{q}{q^2+(1-q)^2}+2q(1-q)\right)+p\left(\frac{q}{q^2+(1-q)^2}-1\right)+\frac{1}{2}\right]$$

Now set $B(p)=c$ and solve for p to obtain the mixed strategy for acquiring information:

$$B(p)=\left(q-\frac{1}{2}\right)\left[p^2\left(\frac{1}{2}-\frac{q}{q^2+(1-q)^2}+2q(1-q)\right)+p\left(\frac{q}{q^2+(1-q)^2}-1\right)+\frac{1}{2}\right]=c$$

$$p^2\left(\frac{1}{2}-\frac{q}{q^2+(1-q)^2}+2q(1-q)\right)+p\left(\frac{q}{q^2+(1-q)^2}-1\right)+\frac{1}{2}=\frac{c}{q-\frac{1}{2}}$$

For simplicity of presentation we denote:

$\alpha=\dfrac{c}{q-\frac{1}{2}}$, $\beta=\dfrac{1}{2}-\dfrac{q}{q^2+(1-q)^2}+2q(1-q)$ and $\gamma=\dfrac{q}{q^2+(1-q)^2}-1$.

$$p=-\frac{1}{2}\frac{\gamma}{\beta}\pm\sqrt{\left(\frac{1}{2}\frac{\gamma}{\beta}\right)^2-\frac{1-2\alpha}{2\beta}}$$

Because probabilities by definition must be positive, we only allow for the positive solution for p. Setting the cost $c=0.125$ and the probability of receiving the correct signal $q=0.75$ there are two possible solutions: $p=0.6154$ or $p=0$.

Appendix C

Example Calculation: Voluntary Voting for n=3

Here, we present an example calculation of the equilibrium probability of acquiring information for the group size $n=3$. First, the gain from acquiring information relative to not has to be determined:

$$B(p) = \left(q - \frac{1}{2}\right)\left(1 - 2p + p^2(1 + 2q(1-q))\right)$$

Now set $B(p) = c$ and solve for p to get the mixed strategy for buying information:

$$1 - 2p + p^2(1 + 2q(1-q)) = \frac{c}{q - \frac{1}{2}}$$

For simplicity of presentation we set $\alpha = \frac{c}{q - \frac{1}{2}}$ and solve for p:

$$p = \frac{2}{1 + 2q(1-q)} \pm \frac{\sqrt{1 - (1-\alpha)(1 + 2q(1-q))}}{1 + 2q(1-q)}$$

Because probabilities by definition must be positive, we only allow for the positive solution for p. Setting the cost $c = 0.125$ and the probability of receiving the correct signal $q = 0.75$ the equilibrium probability of acquiring information is: $p = 0.32071$.

Appendix D

Instructions (Session 1)

(translated from original German version)[46]

General Instructions

Welcome to our experiment. For participating you'll earn 2,50 €. Dependent on your own decisions and the decisions of the other participants you can earn additional money. During the experiment you have the opportunity to collect points. 800 points correspond to 1€. At the end of the experiment your points will be exchanged into € and you will receive amount including the show-up fee in cash. Your payoff is kept anonymous, i.e. no other participant will be informed about your payoff.

Please note that you are never allowed to ask questions aloud or communicate with other participants during the experiment If you have any questions, please raise your hand. One of the experimenters will come to you and answer your questions.

Part I and II

The experiment consists of two parts (Part I and Part II). At the moment, you only have the instructions for Part I. After Part I is over you will receive the instructions for Part II.

Instructions for Part I

Decision rounds and your group

There will be 30 decision rounds. At the beginning of each round the computer will randomly divide the participants into groups of 3 participants each. Beside yourself, your group consists of two other participants. Irrespective of which round you are in, you will never know the other two members of your group. Once again: the composition of your group changes from round to round. In each round you have no business with the other groups!

Correct colour

Before each round the computer randomly determines one and only one of the two colours 'yellow' or 'blue' as the correct colour for your group. Both colours have the same probability

[46] The original instructions may be provided by the authors upon request.

(50%) of being the correct colour. Once again, the correct colour for your group is determined anew before each round.

Decision 'Information"

At the beginning of each round you and the other two members of your group are asked to choose between two alternatives. You can either acquire or not acquire information about the correct colour. If you acquire information it will cost you 25 points, if you do not acquire any information it will cost you nothing (0 points).

The same is true for the two other members of your group. While making this choice, nobody in your group knows the decisions of the other two participants.

Information about the correct colour

Those members of your group who have acquired no information still know that the colours 'yellow' and 'blue' have the same probability (50%) to be the correct colour in this round.

For each member of your group who has acquired information the computer randomly determines an information 'yellow' or 'blue'. This information doesn't tell you for sure which colour is the correct colour for your group in this round. But the information tells you that the colour shown is identical to the correct colour for your group with probability of 75% and is not identical to the colour for your group with probability 25%. The same goes for the other members of your group who have acquired information. Because the computer determines the information 'yellow' or 'blue' for each of the members of your group separately, it may occur that different colours are shown to those members despite the correct colour being the same for all members of your group.

Not you nor any other member will be notified about the decision of any other member about acquiring information and what kind of information that was.

Choice of colour

After the participants who have acquired a signal have been shown a colour, all participants, also the ones not having acquired information, will be asked to choose between three alternatives:

- 'yellow'
- 'blue'

- ‘no colour’

This decision is free of charge (0 points). The same goes for the two other members of your group. While making this decision, no one knows the decisions of the other two members.

Majority decision

After all participants have made their decision ‘yellow’, ‘blue’ or ‘no colour’, the computer sums up the number of choices of ‘yellow’ and the number of choices of ‘blue’ in your group.

The colour with the higher count becomes the majority decision. If both colours receive the same number of decisions (both colours have either ‘no’ decision or both have ‘one’ decision), the computer determines the majority decision randomly: both colours ‘yellow’ and blue’ then have the same probability of becoming the majority decision. The majority decision is always exactly one of the two colours ‘yellow’ or ‘blue’.

Round payoff

To calculate the round payoff for your group the majority decision is compared with the correct colour. Within your group there are two possibilities:

The majority decision is in accordance with the correct colour. Then each member in your group receives a profit of 200 for this round.

The majority decision is not in accordance with the correct colour. Then each member of your group receives a profit of 0 points for this round.

Your payoff for this round is calculated as follows:

Your payoff = your profit – your costs,

Where the costs are equal to 25 points if you acquired information, equal to 0 points if you didn’t acquire information.

The following table shows every possible payoffs in one round:

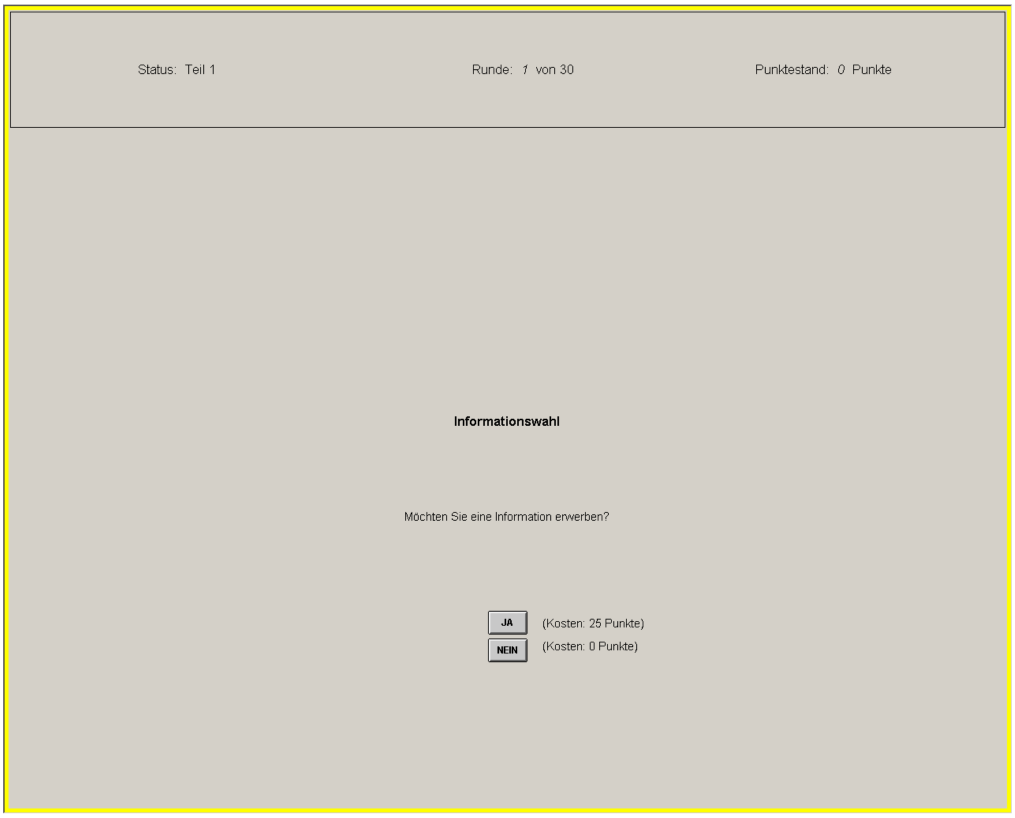
Your decision ‘information’	The majority decision of your group is the correct colour	The majority decision of your group is not the correct colour
Acquire information	175 points	-25 points
Not acquire information	200 points	0 points

The payoffs of the other two members of your group in this round will be calculated in the same way.

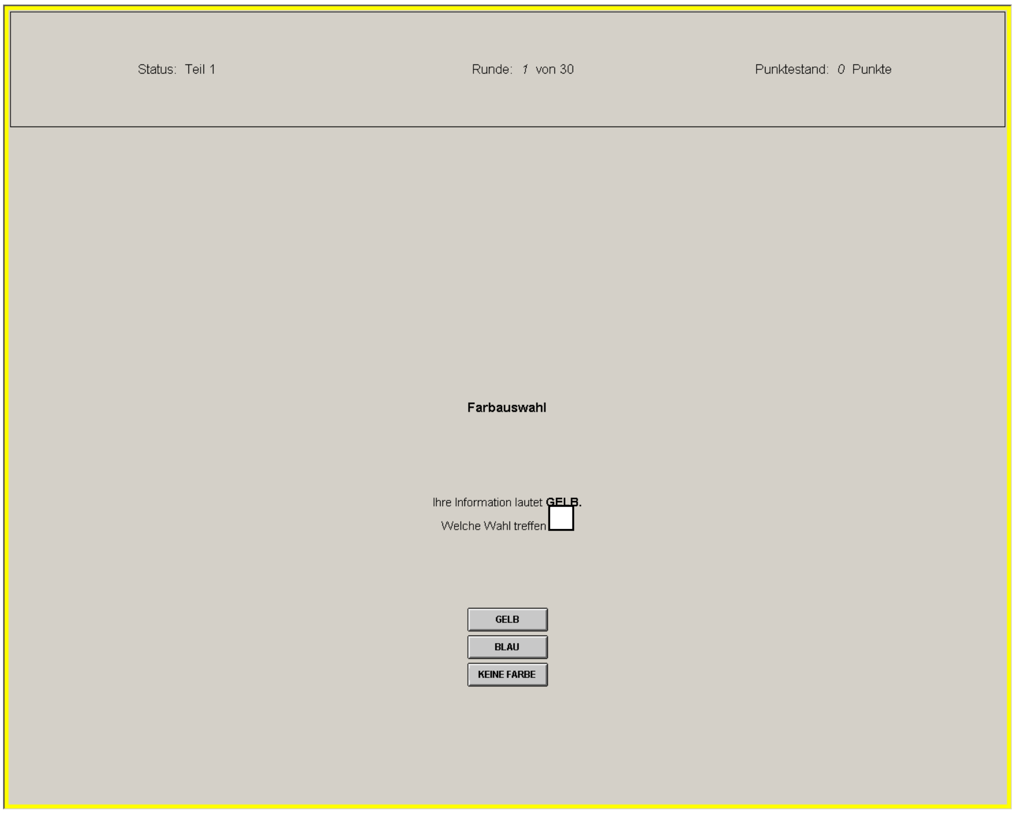
The payoff you receive each round will be added to your personal score after each round. The score shows the sum of all your payoffs per round up to the present round. Only you know your present score .During the whole experiment no other participant will know the score of any other participant.

Computer screens

There are three relevant screens: the screen Choice of Information, the screen Choice of Colour, and the screen Round Result. On each of the three screens you'll find at the upper edge a status bar. Here, you get information about which part (Part I or Part II) you are in, which round (1 through 30) you are in, and your present score.

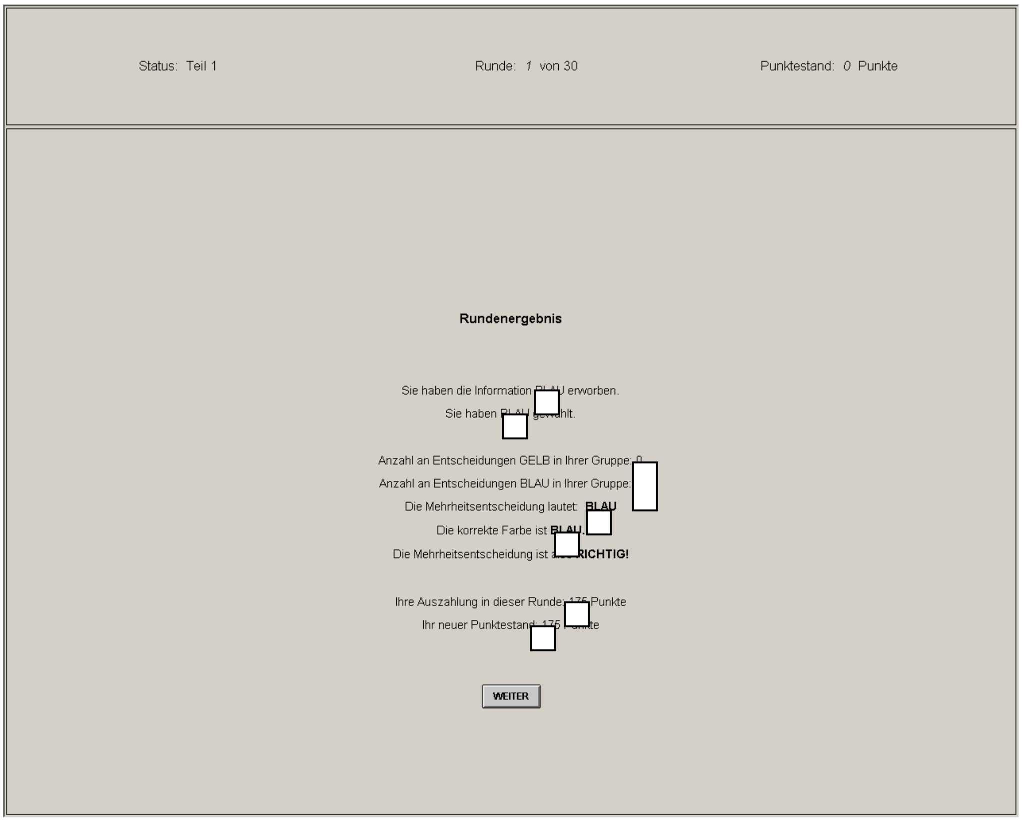


On the screen Choice of Information, click on the button "Yes" if you would like to acquire information. Click on the button "No" if don't want to acquire information.



On the screen Choice of Colour those participants who chose to acquire information will be shown one of the colours ‘yellow’ or ‘blue’. Participants who have not acquired information, are shown no colour.

Furthermore, all participants, that is those who acquired information and those who didn’t, make their choice of colour. Click on the button ‘yellow’ if you choose ‘yellow’, click on the button ‘blue’ if you choose ‘blue’ and click on the button ‘no colour’ if choose ‘no colour’.



On the screen Round Result you receive all relevant information of the round.: if and what information you acquired, your own choice of colour, the number of decisions ‘yellow’ or ‘blue’, the majority decision of your group, the correct colour of your group, your payoff, and your new score.

After having read the screen, please left click on the button “Next” at the lower edge of the screen. Before going to the next round, maybe you’ll have to wait for other participants. In this case you receive the following message: “Please wait until the experiment continues.”

Further course of Part I

Before beginning with Part I, we will hand out a quiz. Please fill in the quiz. The quiz shall assure that all participants have read the instructions for Part I carefully. When you are finished reading the instructions and have filled in the quiz, please raise your hand. One of the experimenters will come to you to answer any of your questions and check your answers to the quiz. Please wait until all participants have finished the quiz. Then we begin with Part I of the experiment and you can earn points.

Instructions for Part II

You have finished Part I of the experiment. Now all participants begin with Part II.

Please note:

At no point during the experiment you are allowed to ask question aloud or to communicate with others.

Part II of the experiment is in most parts identical to Part I. Both parts have one single difference.

The following elements of Part II are identical to Part I:

- 800 points are 1€
- 30 decision rounds
- at the beginning of each round the computer will randomly divide the participants in groups with 3 members each
- participants stay anonymous
- before each round the computer randomly determines ‘yellow’ or ‘blue’ as the correct colour for your group (both colours have the same probability (50%))
- choice of information: acquiring information (25 points) or not acquiring information (0 points)
- majority decision: the colour with the larger number of decisionsis the majority decision of your group
- quality of information: if you acquire information, you will know that the shown colour (’yellow’ or ‘blue’) is identical to the correct colour of your group with probability 75% and does not represent the correct colour for your with probability 25%.

Only difference in Part II:

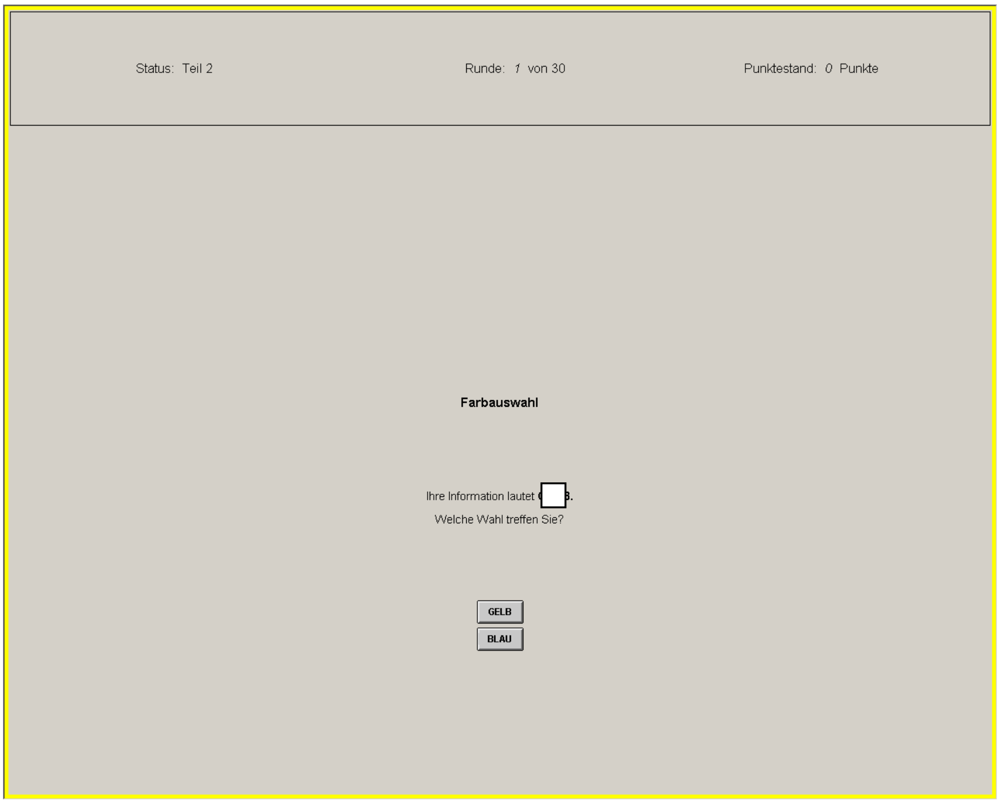
When choosing the colour there are only two alternatives.

After the participants who acquired information have been shown a colour, all participants, also those who didn’t acquire information, are asked to choose between the following two alternatives:

- ‘yellow’
- ‘blue’

This decision is free of charge (0 points). The same goes for the two other members of your group. While making this decision, no one of you knows the decision of each other member.

Note: Because the members of your group have to choose either ‘yellow’ or ‘blue’, both colours having the same number of decisions cannot occur. The majority decision will never be determined randomly.



<u>Further course of Part II</u>

Before beginning with Part II, we will hand out a quiz. Please fill in the quiz. The quiz shall assure that all participants have read the instructions for Part II carefully. When you are finished reading the instructions and have filled in the quiz, please raise your hand. One of the experimenters will come to you to answer any of your questions and check your answers to the quiz. Please wait until all participants have finished the quiz. Then we begin with Part II of the experiment and you can earn points.

The instructions for the other sessions were similar. Because the treatments were played in reversed order, the relevant points were changed on each page.

Quiz (Treatment Abstention)

Please try to answer the following questions.

1. The line-up of your group changes from round to round. Right Wrong

2. In every round there are three participants in your group (you and two other participants). Right Wrong

3. Before every round, the computer randomly determines which colour, “yellow” or “blue”, is the correct colour. Both colours have the same probability (50%) Right Wrong

4. If you acquire information about the correct colour, you will have to bear the cost of 25 points. If you acquire no information about the correct colour, no cost will arise (0 points). Right Wrong

5. If you acquire information you will know that the displayed colour (“yellow” or “blue”) is identical to the correct colour of your group with a probability of 75% and that it does not represent the correct colour in your group with a probability of 25%. Right Wrong

6. Suppose in this round you have decides to choose “blue” and participant X and participant Y have chosen “no colour”. What is the majority decision of group in this round?

7. Suppose in this round you and participant U have decided to choose “yellow” and participant V has chosen “blue”. What is the majority decision of your group ind this round?

8. Suppose you and the other two participants in your group have each chosen “no colour”, so that the number of decisions for “yellow” and “blue” each are equal (zero each). What is the majority decision of your group in this round?

9. In rounds which all participants of your group have chosen “no colour”, each participant automatically receives a payoff of 0 points. Right Wrong

10. Suppose you acquired information and chose the colour “yellow” during the choice of colour. Furthermore, “blue” is the majority decision as well as the correct colour of your group. How large is your payoff in this round?

11. Suppose you acquired no information. Furthermore, “yellow” is the majority decision as well as the correct colour of your group. How large is your payoff in this round?

12. Suppose you have acquired information. Furthermore, “yelloe” is the mahority decision but “blue” is the correct colour of your group. How large is your payoff in this round?

Quiz (Treatment Non-abstention)

Please try to answer the following questions.

1. The line-up of your group changes from round to round. Right Wrong

2. In every round there are three participants in your group (you and two other participants). Right Wrong

3. Before every round, the computer randomly determines which colour, "yellow" or "blue", is the correct colour. Both colours have the same probability (50%). Right Wrong

4. If you acquire information about the correct colour, you will have to bear the cost of 25 points. If you acquire no information about the correct colour, no cost will arise (0 points). Right Wrong

5. If you acquire information you will know that the displayed colour ("yellow" or "blue") is identical to the correct colour of your group with a probability of 75% and that it does not represent the correct colour in your group with a probability of 25%. Right Wrong

6. During the choice of colour you can only choose between "yellow" and "blue". Right Wrong

7. Suppose in this round you have decides to choose "blue" and participant X and participant Y have chosen "yellow". What is the majority decision of group in this round?

8. Suppose you acquired information and chose the colour "yellow" during the choice of colour. Furthermore, "blue" is the majority decision as well as the correct colour of your group. How large is your payoff in this round?

9. Suppose you acquired no information. Furthermore, "yellow" is the majority decision as well as the correct colour of your group. How large is your payoff in this round?

10. Suppose you have acquired information. Furthermore, “yellow” is the majority decision but “blue” is the correct colour of your group. How large is your payoff in this round?