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The Swing Voter's Curse in Social Networks*

Berno Buechel[†] & Lydia Mechtenberg[‡]

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Abstract

We study private communication between jury members who have to decide between two policies in a majority vote. While interests of all agents are perfectly aligned, only some agents (“experts”) receive a private noisy signal about which policy is correct. Each expert can, but need not, recommend a policy to her audience of “non-experts” prior to the vote. We show theoretically and empirically that communication can undermine (informational) efficiency of the vote and hence reduce welfare. Both efficiency and stability of communication hinge on the structure of the communication network. If some experts have distinctly larger audiences than others, non-experts should not follow their voting recommendation. We test the model in a lab experiment and find supporting evidence for this effect and, more generally, for the importance of the network structure.

JEL-Code: *D72, D83, D85, C91.*

Keywords: *Strategic Voting, Social Networks, Majority Rule, Swing Voter's Curse, Information Aggregation, Information Transmission, Jury Voting*

1 Introduction

1.1 Motivation

Majority voting is a major form of collective decision making. As such, it is intensely studied in economics. However, the largest part of the literature ignores communication, although in reality, people often take advice before they vote. For instance,

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family members or neighbors who are more deeply interested in politics or better informed might try to convince others to vote like them.¹ Generally, people often build their opinion on the issues of national referenda after listening to their peers or reading their favorite blog. On a smaller scale, consider a committee, say, of a university faculty. Prior to the official meeting, stressed-out committee members happen to talk to others who had the time to read the documents on which the upcoming committee vote should be based. Some committee members even provide a more or less explicit recommendation on what to decide on an upcoming issue in an upfront email message.² Hence, the question arises whether communication channels that admit such prevote communication are desirable, in particular when designing institutions and organizations, or whether they can even be harmful. Under general conditions, it has been shown that *public* communication leads to efficient information aggregation due to deliberation of private signals (Gerardi and Yariv, 2007 and [Goeree and Yariv, 2011](#)). However, prevote communication need not be public, but can also be – at least partly – *private*, as illustrated by the examples above. Surprisingly, the effects of (partly) private advice on the use of information in voting are largely understudied. To our knowledge, we are the first addressing this issue. Within a common-interest setting, we show that prevote communication in the form of vote recommendations from “experts” to “non-experts” can impede efficient information aggregation even though it is truthful.

A negative effect of private prevote communication on efficiency can occur if the social network connecting voters who are imperfect experts on the issue at stake with initially uninformed voters is not sufficiently balanced, i.e., if one expert has a somehow larger audience of uninformed voters than the other experts. Since in some such networks it is an equilibrium strategy for the uninformed voters to follow the vote recommendation of the experts to whom they are listening, wrongly informed experts may get too much weight in the vote. Then, the voting outcome is less efficient than it would have been in the absence of prevote communication. We show that a sufficient condition for networks in which truthful communication is both a perfect Bayesian equilibrium and harmless can be characterized by an analogous cooperative voting game between the experts in which all experts have the same Banzhaf power index or, likewise, the same Shapley-Shubik index. Based on these theoretical insights, we conducted two experiments that validate the comparative statics of our theory and reveal that in the lab, too, communication sometimes impedes efficient information aggregation.

To better understand when prevote communication can be harmful and when it is harmless, consider communication networks in which experts give private voting recommendations to non-experts and each non-expert listens to one or more experts.³ Such a communication stage is introduced into a standard voting game. Nature draws the binary state of the world and the imperfect but informative signals on it that the experts receive. Both states of the world are equally likely. Each

¹Approximately 30% of the U.S. population report that they give vote recommendations to their peers often or sometimes (see Carpini, Cook, and Jacobs, 2004, p.323).

²We thank Stefan Bühler for this anecdote.

³In the main part of our paper, we consider networks in which each non-expert listens to only one expert; but we extend the model to show how our results generalize if we drop this simplifying assumption.

expert receives only one signal, and signals are independent across experts. Some experts have audiences of one or more uninformed voters and can send one out of two possible messages to their audience or keep silent. Then, a vote takes place to decide which of two possible policies shall be implemented. Only the policy matching the true state of the world generates a strictly positive payoff for all individuals (the other policy generates a zero payoff for everyone).⁴ Experts and non-experts individually and simultaneously decide between voting for one or the other policy and abstaining. Voting is costless.⁵ The policy that gets a simple majority of votes is implemented. In case the voting outcome is a tie, the policy to be implemented is randomly drawn, where both policies have equal probability. Consider now an expert whose audience is a substantial part of the voting population and follows her vote recommendation; i.e., this expert is an opinion leader. Being pivotal with a vote that follows the opinion leader’s recommendation implies that many voters from the rest of the population voted for the opposite, which implies, in turn, that they had information contradicting the opinion leader’s recommendation. Hence, conditioning on pivotality, it is more likely that the voting recommendation of the opinion leader is wrong rather than correct. More generally, in highly unbalanced networks following the vote recommendation is neither informationally efficient nor equilibrium behavior. We theoretically find that the voting equilibria are characterized by informational efficiency if the communication network is sufficiently balanced or sufficiently unbalanced. However, for “mildly unbalanced” communication networks there are voting equilibria that are informationally inefficient due to (truthful) prevote communication. An important feature of our model is that the exogenously given network structure only determines the system of communication channels that can potentially be used, while there is always an efficient equilibrium without communication.

Testing our theoretical predictions in two lab experiments, we find that uninformed voters are indeed more inclined to abstain when they listen to an overly powerful opinion leader, but that abstention still occurs too rarely to prevent a loss in informational efficiency induced by highly unbalanced communication. Experts tend to pass on their information to their audience whenever they feel well informed (in particular in comparison to biased “partisan” senders) but become more reluctant to do so when they are in the position of an overly powerful opinion leader *and* feel not too well informed. In the experiments, the loss in informational efficiency is the larger, the more unbalanced the communication network becomes. Intuitively, the more unbalanced the network structure, the less balanced is power such that the final outcome is determined by the message of a few agents, in contrast to the Marquis de Condorcet’s original idea of aggregating information in the entire collective (De Caritat, 1785).

⁴For instance, a jury has to decide whether to convict or acquit a defendant; or a parliament aiming at protecting their country from a potential aggressor has to decide whether imposing economic sanctions on the latter is helping them to do so.

⁵With costs of voting, the pivot probability which might change across equilibria in different networks would affect the willingness to abstain. Since we want to isolate the effects of communication on voting behavior, we abstract from voting costs. This is also a convention in the literature on jury voting. In the lab, costless voting makes the “willingness to delegate to the expert” harder to find and hence more surprising.

1.2 Related Literature

Condorcet’s argument that majority voting among independently informed voters efficiently aggregates private signals, i.e., his “Jury Theorem,” is a cornerstone of the justification of the majority rule, and, even more generally, of making collective decisions by voting. His argument has been seriously challenged by Austen-Smith and Banks (1996) and Feddersen and Pesendorfer (1996, 1997, 1998) who study voters as strategic actors. As they show, to vote in line with one’s private information, i.e., to “sincerely” cast the vote for the alternative that maximizes unconditional expected utility, is not automatically an optimal decision. When restricting attention to the cases in which one’s own vote is decisive, the resulting conditional expected utility may be different. Hence, we assume strategic voting when solving our model, but also address the question when sincere and strategic voting lead to the same strategies.

In the absence of communication, Feddersen and Pesendorfer (1996) find that it is optimal for rational voters with common interests to abstain if they are uninformed and to vote in line with their independent private signal if they are informed.⁶ This “let the experts decide” behavior not only forms an equilibrium, but also exhibits informational efficiency. In their experimental study of the model of Feddersen and Pesendorfer (1996), Battaglini, Morton, and Palfrey (2010) find that this equilibrium provides a good prediction for real behavior. Morton and Tyran (2011) have extended the model of Feddersen and Pesendorfer (1996) to include heterogeneity in information quality among the informed voters and find that less well informed voters generally tend to abstain and delegate the collective decision to the better informed voters. Hence, the tendency to “delegate to the expert” seems quite strong in the lab. This suggests that the “let the experts decide” equilibrium might be a good prediction even in more general models of information aggregation by majority votes. Accordingly, we consider it to be a benchmark equilibrium in our model, too.

However, the selection of this equilibrium hinges on the assumption that all participating voters enter the majority vote with *independent private* pieces of information – which is fulfilled in the standard model of jury decision making.⁷ But the picture becomes more complicated when a mechanism is introduced that leads to *correlated* information among voters, despite their private independent signals. To our knowledge, the existing literature on jury decision making has considered two such mechanisms: Public communication (deliberation), and additional public

⁶Since Feddersen’s and Pesendorfer’s ingenious contribution, the finding that uninformed jury members are better off abstaining from the vote has been dubbed the swing voter’s curse. More generally, a voter is “cursed” if his optimal strategy conditional on his pivotality differs from what he would deem optimal if he did not condition his strategy on being pivotal, i.e., what he would choose as a dictator. We adopt this way of speaking. If one deviates from the assumption of common interests by introducing a number of “partisans” who always vote into a pre-specified direction, then abstention does no longer need to be the optimal strategy of the uninformed voters.

⁷Levy and Razin (2015) provide a model on informed voting which includes heterogeneous preferences among voters, different sources of information for each voter and voters who neglect the correlation between their information sources. They show that correlation neglect may improve the informational efficiency of the vote since it makes voters put more weight on information than on the conflict of interest. As the the standard model of informed voting with common interests, their model assumes that information remains uncorrelated across different voters.

signals.⁸ Gerardi and Yariv (2007) show that introducing public communication prior to the vote admits the same set of (sequential) equilibria for a whole set of voting rules. Intuitively, the information aggregation that the vote has to achieve in the standard model is shifted up the game tree and is now obtained in the communication stage already. Goeree and Yariv (2011) validate this insight experimentally and document that public communication fosters informational efficiency under general conditions. By contrast, introducing a public signal on the state of the world prior to the vote changes the picture dramatically. Kawamura and Vlaseros (2013) find that the presence of a public signal generates a new class of equilibria in which voters discard their private information in favor of the public signal and information aggregation is inefficient, *even if* voters condition their strategy on their pivotality.

We introduce a third way of correlating voters' information into the standard model of jury decision making: private communication between informed and uninformed jury members. We show that the way in which private communication affects information aggregation is closer to the effects of a public signal than to the effects of public communication: Although efficient equilibria always exist (in particular, of the "let the experts decide" type), there are also equilibria (in particular, of the "sincere" type) in which information is inefficiently aggregated. The latter equilibria and their corresponding "sincere" strategies are more frequently played in the lab than the former such that private communication indeed undermines informational efficiency if some experts are too powerful. In an extension, we study a model that has both private communication and public communication as a special case, and hence builds a bridge between deliberation and the "swing voter's curse."

2 The Model

Nature draws one state of the world, ω , which has two possible realizations, A and B , that occur with equal probability and are not directly observable. There is a finite set of agents partitioned into a group of experts M and a group of non-experts N . Experts $j \in M$ receive a private independent signal $s_j \in \{A^*, B^*\}$ about the true state of the world. The signal is imperfectly informative with quality $p = \Pr\{s_j = A^* \mid \omega = A\} = \Pr\{s_j = B^* \mid \omega = B\} \in (\frac{1}{2}, 1)$. Non-experts $i \in N$ do not receive a signal, but can potentially receive a message from an expert. A bipartite graph g , consisting of links $(i, j) \subseteq N \times M$, represents the communication structure between non-experts and experts. The degree d_i is the number of links of agent i . An expert j with $d_j > 1$ is called sender and all non-experts linked to j are called the "audience of j ." Different audiences do not overlap, i.e., the degree of each non-expert is at most one, and the network structure is common knowledge.⁹

⁸In a recent theory paper, Battaglini (2015) allows for communication between citizens in separate audiences so that information becomes correlated among the citizens in one audience. However, in his model, citizens cannot vote on policies directly but coordinate on public protest instead, potentially signing a petition against the policy maker's default policy. Battaglini shows that communication in social media can improve information aggregation and transmission via public protests.

⁹Under these assumptions on the network structure – being bipartite and admitting each non-expert to have at most one link – no agent can access more than one piece of information. This

After receiving the signal, each sender may send message “A” or message “B” or an empty message $\emptyset$ to her audience. Then, all agents simultaneously participate in a majority vote the outcome of which determines which of two alternative policies, P_A or P_B , shall be implemented. Voters simultaneously vote for one of the two policies or abstain. If one policy obtains a simple majority of votes, it is implemented; otherwise, the policy to be chosen is randomly drawn with equal probability from the two alternatives.

All agents have the same preferences: They want the policy to match the state of the world. More precisely, their utility is $u(P_A|A) = u(P_B|B) = 1$ and $u(P_B|A) = u(P_A|B) = 0$.¹⁰

The sequence of actions is as follows. First, nature draws the state of the world and the signals of the experts. Second, each sender decides which message to communicate to her audience, if any. Third, all agents vote or abstain and the outcome is determined by the simple majority rule. Hence, strategies are defined as follows: A communication and voting strategy σ_j of a sender $j \in M$ defines which message to send and whether and how to vote for each signal received, i.e., $\sigma_j : \{A^*, B^*\} \rightarrow \{A, B, \emptyset\} \times \{A, B, \emptyset\}$ if $d_j \geq 1$ and $\sigma_j : \{A^*, B^*\} \rightarrow \{A, B, \emptyset\}$ if $d_j = 0$. A voting strategy of a non-expert $i \in N$ with a link is a mapping from the set of messages into the voting action $\sigma_i : \{A, B, \emptyset\} \rightarrow \{A, B, \emptyset\}$, and a voting strategy of an agent $i \in N$ without a link is simply a voting action $\sigma_i \in \{A, B, \emptyset\}$. A strategy profile σ consists of all experts’ and all non-experts’ strategies.

We analyze this model using the concept of perfect Bayesian equilibrium, i.e., agents use sequentially rational strategies, given their beliefs, and beliefs are updated according to Bayes’ rule whenever possible. Mostly, we focus on two focal strategy profiles, one with information transmission (“sincere”) and one without information transmission (“let the experts decide”).¹¹ We always assume strategic voting, i.e., voters condition their beliefs on pivotality.

Note that if all non-experts in a given audience choose not to condition their voting action on the message received, then the outcome of the game is as if communication was not possible at all (“babbling equilibrium”). Similarly, if all non-experts in a given audience vote B if the message is A and vote A if the message is B , then the outcome of the game is as if their sender has chosen another communication strategy, where messages A and B are permuted (“mirror equilibria”). We will not differentiate between mirror equilibria, i.e., on the basis of the syntax of information transmission. Instead, we will identify equilibria via the semantics of information transmission, i.e., on the basis of the meanings that messages acquire in equilibrium.¹²

A desirable property of an equilibrium is *informational efficiency* which is defined as follows.

Definition 1. A strategy profile σ is **efficient** if it maximizes the probability of the

assures that information aggregation can only take place in the voting stage but not in the communication stage. In Section 4 we study an extension of the model in which audiences can overlap.

¹⁰Here, we follow the convention to define cardinal utility levels, although this assumption is not necessary.

¹¹A more comprehensive equilibrium analysis is provided in Appendix C.1.

¹²This is standard in the cheap talk literature starting with [Crawford and Sobel \(1982\)](#).

implemented policy matching the true state of the world. Equivalently, a strategy profile σ is efficient if it maximizes the sum of expected utilities of all experts and non-experts.

For a given draw of nature, let us call the signal that has been received by most experts the *majority signal*. In our model, an efficient strategy profile is characterized by always implementing the policy indicated by the majority signal.¹³ For convenience, we let the number of experts $m := |M|$ be odd such that there is always a unique majority signal indicating the policy that *should* be implemented.¹⁴ While the definition of informational efficiency above is binary, strategy profiles can also be ranked according to their informational efficiency by comparing their corresponding probabilities of matching the true state.

Hereafter, we will slightly misuse notation by using “ A ” and “ B ” to denote the corresponding state of the world, signal content, message content, and policy, whenever the context prevents confusion.

2.1 Let the Experts Decide

One important feature of the model is that informational efficiency can always be obtained in equilibrium, regardless of the network structure. Consider for instance the strategy profile σ^* in which all experts vote in line with their signal and all non-experts abstain. Under the simple majority rule this “let the experts decide” strategy profile σ^* is efficient since for any draw of nature the signal received by a majority of experts is implemented. Moreover, because preferences are homogeneous, efficient strategy profiles do not only maximize the sum of utilities, but also each individual agent’s utility. Thus, there is no room for improvement, as already argued in McLennan (1998).

Proposition 1. *There exist efficient equilibria for any network structure. For instance, the “let the experts decide” strategy profile σ^* is efficient and an equilibrium for any network structure.*

Importantly, while efficient strategies constitute an equilibrium, the reverse does not hold true: Existence of an equilibrium does not imply that it is efficient. On the contrary, there are (trivial and non-trivial) inefficient equilibria of the game. One non-trivial inefficient equilibrium will be discussed as Example 3 below.

Among the efficient equilibria, we consider the “let the experts decide” equilibrium σ^* focal for two reasons. First, it is simple: All experts use the same type of strategy and all non-experts use the same type strategy. Second, it is intuitive to abstain as a non-expert and to vote one’s signal as an expert, as already argued, e.g., by Feddersen and Pesendorfer (1996). However, since it is also intuitive for experts

¹³Given efficient strategy profiles, the probability of matching the true state is maximized but not equal to one because it might always happen by chance that most experts receive the wrong signal. Letting the number of experts grow, this probability approaches one as in Condorcet’s Jury Theorem.

¹⁴Admitting an even number of experts would not change the results qualitatively, but it would make the analysis cumbersome because more cases had to be distinguished.

to send informative messages and for receivers to vote according to their messages, it may nonetheless be difficult to coordinate on σ^* . In particular, consider the strategy profile $\hat{\sigma}$ in which experts communicate and vote their signal and non-experts vote their message and abstain if they did not receive any information. This strategy profile $\hat{\sigma}$ is *sincere* in the sense that each agent communicates and votes the alternative that she considers as most likely given her private information.¹⁵ We now proceed by investigating the sincere strategy profile.

2.2 Sincere Voting

Balanced networks. To characterize under which conditions on the network structure the sincere strategy profile $\hat{\sigma}$ is an equilibrium and how the network structure affects the extent to which $\hat{\sigma}$ aggregates the experts' information efficiently, we use the following definition.

Definition 2 (Balancedness). *Order the degree distribution in M in decreasing order $(d_1, d_2, \dots, d_m)$ such that $d_j \geq d_{j+1}$; and denote the number of links by $l := \sum_{i=1}^m d_i$.¹⁶ For $m = |M| \geq 5$ and m odd, we call a network*

- (a) “strongly balanced” if at most half of the links are concentrated on the highest-degree expert and the $\frac{m-3}{2}$ highest-degree other experts, i.e., $d_1 + \sum_{j=2}^{\frac{m-1}{2}} d_j \leq \frac{l}{2}$; and
- (b) “weakly balanced” if at most half of the links are concentrated on the highest-degree expert and the $\frac{m-3}{2}$ lowest-degree experts, i.e., $d_1 + \sum_{k=\frac{m+5}{2}}^m d_k \leq \frac{l}{2}$.

Proposition 2. *Let $m = |M| \geq 5$, let m be odd, and let the number of links $l := \sum_{j=1}^m d_j$ be even. The sincere strategy profile $\hat{\sigma}$ is an equilibrium if (a) the network is strongly balanced, and only if either (b) the network is weakly balanced or there is an agent who is never pivotal. The sincere strategy profile $\hat{\sigma}$ is efficient if and only if (a) the network is strongly balanced.*

Strong balancedness and hence the sufficient condition (a) of Proposition 2 is illustrated in the following example.

Example 1 (strongly balanced). *Let $n = 4$, $m = 5$, and the degree distribution of experts $(d_1, d_2, d_3, d_4, d_5) = (1, 1, 1, 1, 0)$ as illustrated in the left panel of Figure 1. This network is strongly balanced (since $d_1 + d_2 \leq \frac{l}{2}$ which is $2 \leq 2$). By Proposition 2 the sincere strategy profile $\hat{\sigma}$ is efficient and an equilibrium.*

Observe in the example that under the sincere strategy profile $\hat{\sigma}$ any three experts who vote and communicate the same alternative determine the final outcome. Thus, for any draw of nature the policy indicated by the majority signal is implemented, which means that information is aggregated efficiently and hence $\hat{\sigma}$ is an equilibrium.

¹⁵The “let the experts decide” strategy profile σ^* , in contrast, is not “fully sincere” for the following reason. The aspect that information is not transmitted either means that senders do not communicate their signal or that receivers do not follow their message.

¹⁶If two experts have the same degree, then the ordering does not matter.

Strong balancedness is a strong condition on the equality of the degree distribution. In the proof of Proposition 2 we show that strong balancedness is not only equivalent to efficiency of the sincere strategy profile $\hat{\sigma}$, but also equivalent to the following property of $\hat{\sigma}$: The hypothetical outcome of a vote in which the experts M alone participate coincides with the outcome of voting in the entire society $M \cup N$ for any realization of the draws of nature (cf. Lemma B.1).

Consider now weak balancedness. Proposition 2 states that if all players can be pivotal under the sincere strategy profile $\hat{\sigma}$, then weak balancedness is a necessary condition for $\hat{\sigma}$ to be an equilibrium. Necessity can be illustrated with an example of a network that violates weak balancedness when showing that $\hat{\sigma}$ is not an equilibrium. Networks violating weak balancedness also violate strong balancedness and will be called “unbalanced” hereafter.

Example 2 (star). *Let $n = 4$, $m = 5$, and the degree distribution of experts $(d_1, d_2, d_3, d_4, d_5) = (4, 0, 0, 0, 0)$ as illustrated in the right panel of Figure 1. This network violates weak balancedness (since $d_1 + d_5 \not\leq \frac{1}{2}$ which is $4 \not\leq 2$) and therefore also strong balancedness. Hence, by Proposition 2 the sincere strategy profile $\hat{\sigma}$ is neither efficient nor an equilibrium (every voter is pivotal for some draw of nature).*

To see why $\hat{\sigma}$ is inefficient in the example, consider a draw of nature by which the most powerful expert, i.e., the expert with the highest degree, receives the minority signal. Assume now, for the sake of argument, that the sincere strategy profile $\hat{\sigma}$ is played. In this case the minority signal determines which policy is implemented; information is hence aggregated inefficiently. To see why $\hat{\sigma}$ is not an equilibrium, consider the following two deviation incentives. First, the most powerful expert would want to deviate to not communicating, but still voting, her signal. This would lead to an efficient strategy profile of the “let the experts decide” type. Second, the non-experts, too, can improve by deviating. In particular, consider a non-expert receiving message A . His posterior belief that A is true is $p_i(A|A) = p > \frac{1}{2}$. However, his posterior belief that A is true, given that he is pivotal, is $p_i(A|A, \text{piv}) < \frac{1}{2}$ because in this simple example pivotality only occurs when all other experts have received signal B . Thus, abstention or voting the opposite of the message is a strict improvement for any non-expert.

Example 2 provides a simple illustration of the swing voter’s curse. The argument, however, is much more general. Assume that all agents play according to the sincere strategy profile $\hat{\sigma}$ and consider the receivers who belong to the largest audience. These receivers know that their sender is very powerful. Hence, if they are pivotal in the vote, this implies that a considerable number among the other experts must have got a signal that contradicts the message they received. Thus, if following the message has any effect on the outcome, it has most likely a detrimental effect. If a receiver in the largest audience realizes that he is “cursed” in this sense, he wants to deviate from the *sincere* strategy and prefers to abstain or to vote the opposite.

In fact, this is the intuition for the proof of the necessary condition in Proposition 2. If condition (b) does not hold, an agent i listening to the most powerful sender infers from her pivotality that the received message must be the minority signal and is thus less likely to match the true state of the world than the opposite choice.

Figure 1

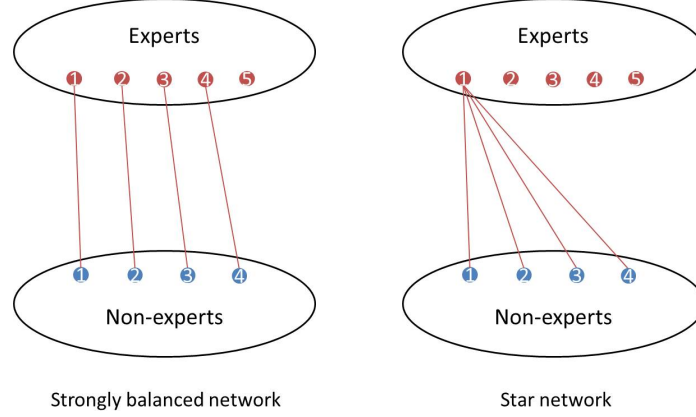


Figure 1: Left: Example 1, which is a network satisfying strong balancedness. Right: Example 2, the star network, which is an unbalanced network.

Weighted majority games. Proposition 2, in particular sufficiency, can also be re-interpreted in terms of expert power as defined in so-called *weighted majority games* (cf., e.g., Roth, 1988). To see this, note that our model defines a non-cooperative game under incomplete information which is specified by an exogenous network g . To each of these games $\Gamma(g)$, we can associate a cooperative game (M, v) , i.e., a cooperative game among the experts, with the characteristic function $v : 2^M \rightarrow \{0, 1\}$ such that a coalition $S \subseteq M$ is winning, i.e., $v(S) = 1$, if and only if this coalition of experts together with their audiences have a majority of votes, i.e., $\sum_{j \in S} (d_j + 1) > \frac{m+l}{2}$. This is a weighted majority game among experts in which each expert j 's weight is $d_j + 1$, making the implicit assumption that all non-experts linked to an expert follow her recommendation, as it is the case under $\hat{\sigma}$.

In weighted majority games, a player's *power* is measured by the Shapley value, which is then called the Shapley-Shubik index, or alternatively, with the Banzhaf index. Both indices take into account how often a player can “swing” a losing coalition into a winning coalition. In the weighted majority game, for instance, corresponding to Example 1, i.e., the majority game with weights $(w_1, \dots, w_5) = (2, 2, 2, 2, 1)$ and quota 5, all players are equally powerful since the winning coalitions are those which have at least three members. The upcoming corollary of Proposition 2 shows that this observation fully generalizes.

Definition 3 (Power). For a network g , define **power** of an expert $j \in M$ as her Banzhaf index $\beta_j(v)$ or her Shapley-Shubik index $\phi_j(v)$, in the corresponding weighted majority game (M, v) with $v(S) = 1$ if and only if $\sum_{j \in S} (d_j + 1) > \frac{m+l}{2}$. The (raw) Banzhaf index of an expert $j \in M$ is the fraction of swings she has, i.e., $\beta_j(v) = \frac{1}{2^{m-1}} \sum_{S \subseteq M \setminus \{j\}} [v(S \cup \{j\}) - v(S)]$; the Shapley-Shubik index (SSI) of an expert $j \in M$ is her marginal contribution averaged over all orderings of the experts, which can be written as $\phi_j(v) = \sum_{S \subseteq M \setminus \{j\}} \frac{|S|!(m-|S|-1)!}{m!} [v(S \cup \{j\}) - v(S)]$.

Corollary 1. Let m and l be as in Proposition 2. The sincere strategy profile $\hat{\sigma}$ is an equilibrium if (a) all experts are equally powerful in the corresponding weighted majority game (M, v) and only if either (b) the coalition consisting of the most

powerful expert and the $\frac{m-3}{2}$ least powerful experts is not winning in (M, v) or there is an agent who is never pivotal. Moreover, the sincere strategy profile $\hat{\sigma}$ is efficient if and only if (a) all experts are equally powerful.

The corollary is a simple reformulation of Proposition 2 using that (a) strong balancedness is equivalent to equally powerful experts and (b) weak balancedness is equivalent to $v(M') = 0$ when M' consists of the most powerful expert together with the $\frac{m-3}{2}$ least powerful experts. Recalling that experts are equally well informed, it is intuitive that equal power of experts means efficiency of $\hat{\sigma}$.¹⁷ To illustrate the necessary condition (b), we observe that the existence of a *dictator*, i.e., a player j who has a swing in every coalition $S \subseteq M \setminus \{j\}$, leads to a violation of the necessary condition. In particular, a dictator has the maximal Banzhaf index and the maximal Shapley-Shubik index of one and any player following the dictator's message is "cursed" in the sense that if the own vote is decisive under $\hat{\sigma}$, then the opposite of the message is preferred. An example illustrating this effect is given by the weighted majority game corresponding to Example 2, i.e., the majority game with weights $(w_1, \dots, w_5) = (5, 1, 1, 1, 1)$ and quota 5, in which expert 1 has dictatorial power.¹⁸

Inefficient equilibria. Note that Proposition 2 (as well as Corollary 1) provides one sufficient and one necessary condition for the sincere strategy profile $\hat{\sigma}$ to be an equilibrium, but no condition that is both sufficient and necessary. For such a condition, see Proposition C.5 in Appendix C.2. For networks that satisfy the necessary condition (weak balancedness), but violate the sufficient condition (strong balancedness) the sincere strategy profile $\hat{\sigma}$ is inefficient but potentially still an equilibrium. More generally, the question arises whether there are equilibria with information transmission prior to the vote that are inefficient.

Proposition 3. *There are networks in which the sincere strategy profile $\hat{\sigma}$ is both an equilibrium and exhibits informational inefficiency.*

One example demonstrating the above proposition is given below.

Example 3 (weakly balanced). *Let $n = 4$, $m = 5$, and the degree distribution of experts $(d_1, \dots, d_5) = (2, 2, 0, 0, 0)$ as illustrated in Figure 2. In this network the sincere strategy profile $\hat{\sigma}$ is inefficient because the network violates strong balancedness. However, the sincere strategy profile $\hat{\sigma}$ is an equilibrium in this network (see proof of Proposition 3 in Appendix B).*

Overall, we can conclude that communication need not, but can impair information aggregation in equilibrium, depending on the balancedness of the network structure. In strongly balanced networks (such as in Example 1), $\hat{\sigma}$ is both efficient and an equilibrium. In weakly balanced networks that are no longer strongly balanced (such as in Example 3), $\hat{\sigma}$ can still be an equilibrium, but is always informationally inefficient. Finally, in unbalanced networks (such as in Example 2) neither property holds. There the swing voter's curse occurs such that non-experts can profitably deviate from $\hat{\sigma}$ by not following their message.

¹⁷In section 5 we discuss and relax the assumption of equal signal precision.

¹⁸The weighted majority games corresponding to Examples 1 and 2 are extreme cases with minimal, respectively maximal, inequality of expert power.

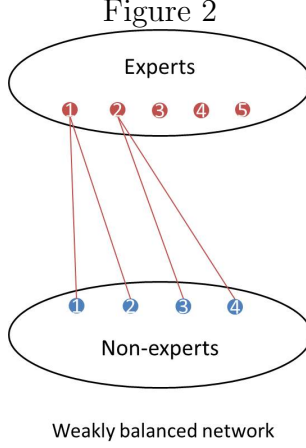


Figure 2: Example 3, a network in which the sincere strategy profile $\hat{\sigma}$ is both inefficient and an equilibrium.

2.3 Equilibrium Selection

Whether real people account for the swing voter’s curse in unbalanced networks is an empirical question. Therefore, it may be helpful to bring the theory to the lab and find out how experimental subjects play the game in various networks that differ in the balancedness of their degree distribution. Hence, the first purpose of the laboratory experiment is to test the comparative-statics of our theory. The second purpose is to empirically study equilibrium selection. In particular, in the case of weakly balanced networks that are not strongly balanced the quality of information aggregation depends on whether the agents manage to coordinate on the efficient “let the experts decide” equilibrium or whether they coordinate on the inefficient sincere equilibrium, or on other potential equilibria. This question is hard to answer theoretically, since both the “let the experts decide” strategy profile σ^* and the sincere strategy profile $\hat{\sigma}$ are intuitive and hence focal.

To theoretically prepare the experimental equilibrium selection, we also have to address the question of additional, non-focal equilibria. To illustrate the types of strategy profiles that, in addition to the “let the experts decide” strategy profile and the sincere strategy profile, can become equilibria, we extend the equilibrium analysis of our Examples 1, 2, and 3. This is particularly useful since these examples are also implemented in our experiment. In Appendix C.1, we give a full characterization of all equilibria conforming to four selection criteria (Purity, Symmetry, Monotonicity, and Neutrality). It shows that one more strategy than considered so far contributes to equilibrium formation, namely a *delegation* strategy according to which experts with an audience delegate their vote to their audience by revealing their signal and abstaining themselves. Moreover, there are equilibria in which experts who are never pivotal abstain from voting without delegating their vote. However, there are no additional strategy profiles that arise as equilibria in these examples. All equilibria conforming to our selection criteria are composites of the “let the experts decide” strategy profile, the sincere voting profile, and the delegation or abstention strategies of experts.

2.4 Extension: Partisans and Propaganda

So far, we have assumed that non-experts listening to a sender can always trust in common interests. This, however, need not be true in reality. Experts might be secretly biased and send out wrong information in order to win the uninformed over into unknowingly supporting their own particular interests. In this case, non-experts would often wrongly trust to get truthful advice. Hence, we extend our model to include biased senders, i.e., “partisans” who have strict preferences for one of the two policies, regardless of the state of the world. Partisans preferring policy P_A (P_B) will be called A -partisans (B -partisans). In the extended model, non-experts are aware of the presence of partisans, but cannot tell partisans from honest experts and hence can no longer be sure that they listen to someone sharing their interest in matching the true state of the world. We only consider networks with the same number of A - and B -partisans which has basically the same effect as decreasing the expected reliability that non-experts ascribe to their sender’s message. In Appendix C.3, we provide a full description of the extended model and show that, unsurprisingly, all theoretical results obtained for the model without partisans (Propositions 1-3) also hold true for the model with partisans (Propositions C.6-C.8). This extension serves a twofold purpose: First, it shows that our results are robust in a more realistic setting in which a “sender” of information on the state of the world is not always an honest expert but can also be biased. Second, it captures some aspects of propaganda since in reality, partisans and experts both communicate to audiences of different size, for instance via internet blogs. Hence, it is of some interest to test whether propaganda can have an unlimited influence on the outcome of votes in which the uninformed and the experts have the common interest of “getting it right,” or whether there is an upper limit to the influence of propaganda due to the deviation incentive that drives non-experts in over-sized audiences to abstain.

3 The Experiment

In the experimental part, we address two questions: First, do real people forming the audience of a potentially informed sender understand that they should stop voting in line with their sender’s recommendation if the audience becomes too large compared to the audiences of other senders? That is, do they act in accordance with the comparative statics of our model? If the answer is yes, this will have the following consequences. There will be a limit to sincere voting in networks that are not strongly balanced and to the resulting informational inefficiency. Moreover, there will be an upper limit to the influence that partisan propaganda can have on the outcome of votes in which all non-partisans want to implement the “right” policy. The second question addressed by the experiments is whether private communication in networks of varying balancedness can lead to significant inefficiencies in information aggregation. This would be true if all participants played sincerely, but, recall, there is always the option to play “let the experts decide” which is efficient and an equilibrium.

3.1 Experimental Design

We conducted two experimental studies. In Study I, we implement the empty network, in which communication is precluded, and the three examples – Example 1, 2, and 3 – analyzed above. The empty network serves as a benchmark, since the sincere strategy profile $\hat{\sigma}$ is impossible to play in the empty network because no sender can send any message in the empty set. Hence, the “let the experts decide”-equilibrium is the only focal equilibrium in the empty network. The other three networks differ in the way described in section 2.2. Hence, Study I directly tests our unextended model.

In Study II, we again implement the empty network and three examples, the latter, however, now belonging to the extended version of our model that includes biased senders. These four networks differ in the following respects: Network 1 is the *empty network*. Network 2 is the *weakly balanced network* and is the unique network among the four in which the sincere strategy profile $\hat{\sigma}$ is both an equilibrium and inefficient, as demonstrated in the proof of Proposition C.8. Network 3, which we will call the *unbalanced network*, makes sender 1 too powerful compared to the other sender, and the strategy profile $\hat{\sigma}$, which is again inefficient, is no longer an equilibrium, though possible to play. The same holds true for network 4, the *star network*, which is even more unbalanced.

In total, our experimental design implements the eight different communication networks depicted in Figure 3. Each of these networks corresponds to one experimental treatment; and within each study, treatments are varied within subjects (i.e., all participants in a given session of one study play the communication and voting game in all four networks) in random order.

Comparing the networks in Study I with those in Study II, we can summarize that both studies implement the empty network (in which information transmission is precluded), a weakly balanced network (in which $\hat{\sigma}$ is an equilibrium), and the star network (in which $\hat{\sigma}$ is not an equilibrium).¹⁹ While Study I accompanies the weakly balanced network with a strongly balanced network to have an example in which $\hat{\sigma}$ is efficient, Study II accompanies the star network with an unbalanced network that features different sender degrees within one treatment. Apart from the baseline treatment, the empty network, the density of the networks is held constant while the equality of the degree distribution is decreasing. Moreover, the *expected* probability of a message being true in the sincere strategy profile, given that the receiver in Study I knows that he listens to an expert, while the receiver in Study II does not know whether he listens to a partisan or an expert, is approximately equal and hence roughly comparable in both studies. Hence, we chose to keep the environment of Study II similar to Study I for the non-experts, consequently changing it quite a bit for the experts. We made this choice since our interest in the non-experts is more intense than our interest in the experts. In sum, Study I and Study II are not directly comparable, but similar with regard to the non-experts. The clear-cut comparisons are across treatments within each study.

¹⁹Note that the second network in Study I and the second network in Study II look quite similar, but are essentially different: The former is strongly balanced, the latter only weakly balanced.

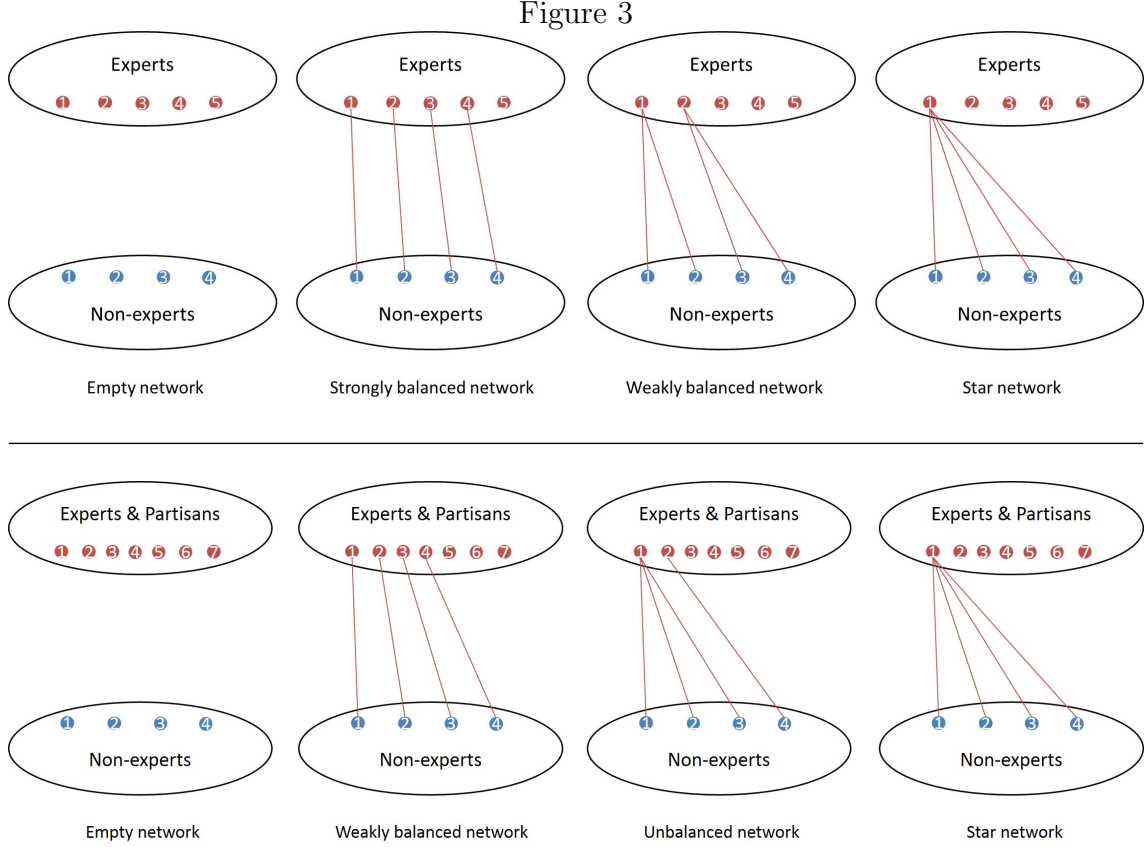


Figure 3: Upper panel: The four treatments of the Study I. Lower panel: The four treatments of the Study II.

3.2 Experimental Implementation

The experiments were conducted in the WISO-lab of the University of Hamburg in November 2014 and August and September 2015, using the software z-Tree. We ran seven sessions within Study I and five sessions within Study II with $3 \times 9 = 27$, respectively $4 \times 7 = 28$, participants in each session. All subjects in a session played the game described above in all four networks over 40 rounds in total. At the beginning of each session, subjects randomly received the role of an expert or the role of a non-expert. These roles were fixed throughout the experiment. In each round, subjects were randomly matched into groups of eight in Study I and groups of seven in Study II. Groups consisted of four experts and four non-experts in Study I and three experts and four non-experts in Study II. The four partisans in Study II were computerized. In line with the equilibrium behavior in the extended model, *A*-partisans always vote *A* and send the message *A*, and *B*-partisans always vote *B* and send the message *B*. Groups were newly formed each round by random re-matching. Each network game was played in ten rounds in total, but the order of networks across rounds was randomized. Instructions that described the experimental session in detail were handed out at the beginning of each session and were followed by a short quiz that tested the subjects' understanding

of the game.²⁰ Hence, the experiment started only after each subject understood the rules of the game. Moreover, there were four practicing rounds, one for each treatment, that were not payout relevant. During the entire session, each subject always knew his own network position and the structure of the network. The quality of the signal that the experts received was $p = 0.6$ in Study I and $p = 0.8$ in Study II which guaranteed that the expected probability of a non-empty message being true under the sincere strategy profile was approximately equal across both studies. At the end of each session, three rounds were randomly drawn and payed out in cash and in private. On average, sessions in Study I and Study II lasted for 1.5 hours and subjects earned EUR 14.3 and EUR 16.7, respectively.²¹

3.3 Results

Table 1 in Appendix A gives a summary of the number of observations. On the group level we have 840 and 800 observations in Study I and Study II, respectively. On the individual level we have 7,560 (5,600) observations in Study I (II) with 40 decisions per subject. In total, 189 (Study I) and 160 subjects (Study II) participated in the experiments.

Pooling all treatments, experts vote for the signal they received 84% and 92% of times in Study I and II, respectively. If they have an audience they also communicate their signal 75% and 90% of all times. Those who do not communicate their signal usually send an empty message. Non-experts vote in line with their received message on average 69% and 57% of all times. Those who receive a non-empty message but do not follow it usually abstain. Abstention is also the most common behavior of non-experts who did not receive a message. As these first descriptives suggest, the behavior of non-experts exhibits more variance than expert behavior, in particular in Study II, but also in Study I. Hence, we examine treatment effects for non-experts and experts sequentially. After analyzing individual behavior in section 3.3.1, we will turn to the question of efficiency in section 3.3.2. All tables reporting our experimental results can be found in Appendix A.

3.3.1 Results on Individual Behavior Across Networks

First, we analyze under which conditions on the network structure non-experts who receive a vote recommendation follow it, i.e., whether laboratory participants account for our novel form of the “swing voter’s curse.” Second, we investigate communication behavior of experts, i.e., when participants pass on their signal to their audience. Third, we address equilibrium selection.

Following of vote recommendations. Non-experts in our experiments receive vote recommendations. Apart from the empty treatments, every non-expert is linked to an expert sender, who in most cases sends a non-empty message. The equilibrium analysis of our model showed that the vote recommendation of an expert should

²⁰The instructions can be found in Appendix D.

²¹The norm in the WISO-lab at the University of Hamburg is EUR 10 per hour.

Figure 4

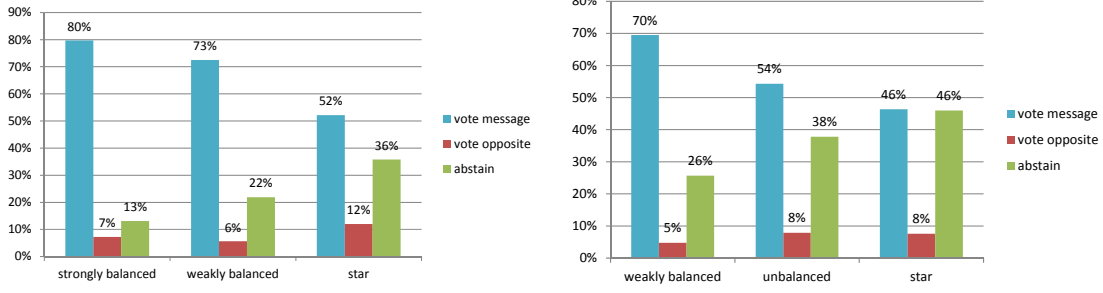


Figure 4: Frequency of non-experts' following behavior by treatment. Vote message means to vote A (B) when the message received is A (B). Vote opposite means to vote A (B) when the message received is B (A). Displayed are responses to non-empty messages. The left panel displays results for Study I. The right panel displays results for Study II.

only be followed if this expert is not “too powerful” in terms of audience size. More precisely, the sincere strategy profile $\hat{\sigma}$ in which all non-experts follow their messages is an equilibrium in the strongly and weakly balanced networks of our experiments, but not in the unbalanced network and the star network (which is also unbalanced).²² As displayed in Figure 4 (and in Table 2 in column ‘vote message’), in around 70% to 80% of the cases non-experts vote according to their received message in the balanced networks, where the sincere strategy profile is an equilibrium, but they do so only in around 50% of the cases in the unbalanced networks such as the star. These differences are highly significant as can be seen from the logistic regressions in Table 3, which take the weakly balanced networks as the baseline category. This holds independent of whether we restrict attention to non-experts who received a non-empty message or whether we also consider abstaining in the case of an empty message as “following.” Moreover, regressions in Tables 3a even show that non-experts tend to follow vote recommendations most often in the strongly balanced network, in which the sincere strategy profile is not only an equilibrium but also efficient.

To get more detailed evidence on when non-experts follow their vote recommendations, we move on to heterogeneity among individual participants. Figure 5 shows how many of the non-experts never and how many always followed their message in a given position. As many as 57%, respectively 46%, of the non-experts always follow their message when they are in the strongly balanced network, respectively the weakly balanced network. For the star network this number reduces to 30% (25%) in Study I (II), strongly suggesting that non-experts react to the relative degree of their sender, as predicted by theory.

To further test this hypothesis, it is useful to observe how the network *position* affects behavior of the non-experts on top of the network type. Since sender degree and network type are almost perfectly correlated in our experimental setting, we can do so only by concentrating on the unbalanced network of Study II in which the degree varies across senders. In the unbalanced network of Study II, non-experts in

²²In the experiments, around 80% of the time experts play the sincere strategy $\hat{\sigma}_j$, and only around 5% of the time they send a message that contradicts their signal (Table 5).

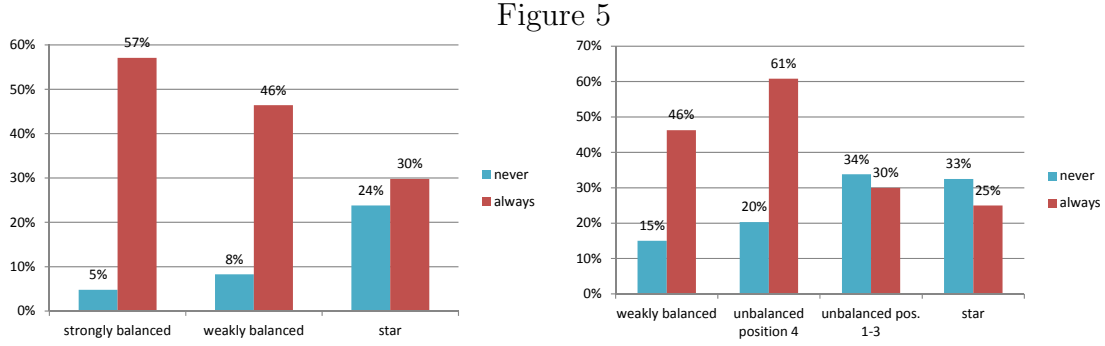


Figure 5: Frequency of individual following behavior by treatment (and position). The variable ‘never’, respectively ‘always,’ reports the fraction of individual participants who never respectively always followed the non-empty vote recommendation they received for each network position. The left panel displays results for Study I. The right panel displays results for Study II.

positions 1-3 are linked to a sender with degree three such that following her message is not a best response to the sincere strategy profile $\hat{\sigma}$. By contrast, the non-expert in position 4 who is linked to the sender with degree one should best respond to $\hat{\sigma}$ by following his message. As can also be seen from Figure 5, 61% of the subjects always follow their message when they listen to the sender with degree one, while only 30% do so when linked to the sender with degree three. Differences in individual behavior across positions are tested with Wilcoxon signed-ranks tests, which are reported in Table 4: When the sender has degree three or four (i.e., in the star network and in the unbalanced network in positions 1-3) the non-experts’ following behavior is different from their behavior in all other network positions. When including situations in which individual participants receive an empty message (lower block of Table 4), the same picture arises. Hence, the sender’s (relative) degree has a strong influence on following: a substantial fraction of individuals never follows the vote recommendation of too influential senders, while another substantial fraction always follows.

Non-experts who do not follow a non-trivial message mostly abstain, as can be seen, e.g., in Figure 4. Thus, the flipside of a significant decrease in followers is a significant increase in abstentions for the unbalanced networks.

Result 1. *Non-experts linked to the expert with the highest degree follow their vote recommendation significantly more often in the (strongly and weakly) balanced networks than in the unbalanced networks (i.e., the star and the unbalanced network). Within a given unbalanced network, non-experts linked to the sender with the highest degree follow significantly less often than non-experts linked to the sender with the lowest positive degree.*

Vote recommendations of experts. As mentioned earlier, around 80% of the time experts vote and communicate in accordance with their signal, which is playing the sincere strategy $\hat{\sigma}_j$ (Table 5). While experts vote in line with their signal in a large majority of cases, there are some deviations from the sincere strategy profile on the communication stage, as can be seen from Figure 6. Information transmission is lowest in Study I in the star network, where only 61% of the senders communicate

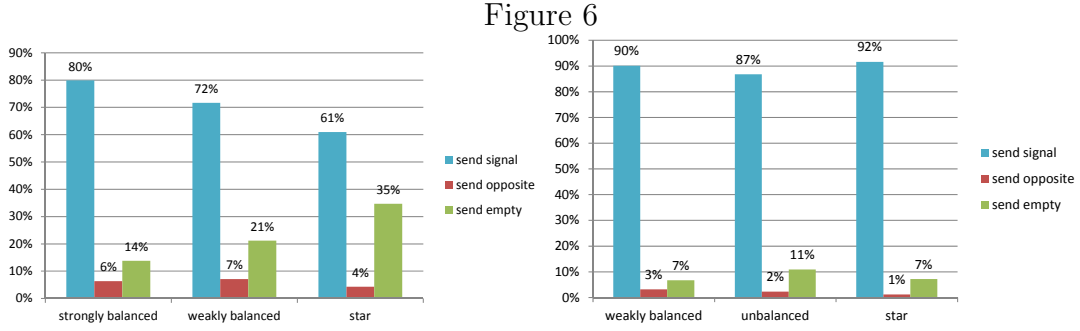


Figure 6: Frequency of experts' communication behavior by treatment. Send signal means to send message A (B) when the signal received is A (B). Send opposite means to send message A (B) when the signal received is B (A). The left panel shows results for Study I. The right panel shows results for Study II.

their signal, whereas 35% choose the empty message. This is a significant difference in communication behavior, as Table 6a reveals. Moreover, experts send a truthful message more frequently in the strongly balanced network than in the weakly balanced network. These effects are not present in Study II (Table 6b).²³

To further analyze whether experts condition their behavior on the network structure and their position, we inspect heterogeneity among individual participants. In Study I, experts' behavior in the star network differs from their behavior in the other treatments, both when comparing only senders, i.e., experts with a link, and only non-senders. This is revealed by Wilcoxon signed-ranks test (Table 7). Both senders and non-senders are more often sincere in the balanced networks, where this is a best response to the sincere behavior of all others, than in the (unbalanced) star network, where this is not a best response. In particular, around 32% of the senders in the star network never choose the sincere strategy profile in Study I. The fact that in 73% of these latter cases the signal determines the vote and the empty message is chosen is an indication that these experts actively target the “let the experts decide” equilibrium. Interestingly, this effect cannot be observed in Study II, in which partisans are present and in which signal quality of experts is lower. In Study II, experts are sincere in a large majority of cases and there are no systematic deviations from this strategy.²⁴

Thus, although some experts seem to target the “let the experts decide” equilibrium in the star network in Study I, most of the time experts play sincere, independent of the communication structure. Note that this does not necessarily imply that those experts never target the “let the experts decide” equilibrium; it might also mean that the subjects in the role of the experts intentionally delegate equilibrium

²³The latter effect cannot be addressed by Study II since there is no treatment with a strongly balanced network. The former effect, i.e., the reluctance to send the signal in the star network, may vanish in Study II based on a behavioral reaction to the presence of partisans or to the higher signal quality.

²⁴The only difference in expert sincerity that is significant on the five percent level in Study II occurs when comparing the unbalanced network with the star network. This effect suggests that experts without a link less often vote their signal in the unbalanced network than in the star network. Since both these networks are unbalanced, the sincere strategy profile is not an equilibrium in any of them and hence the effect is outside of what our theory addresses.

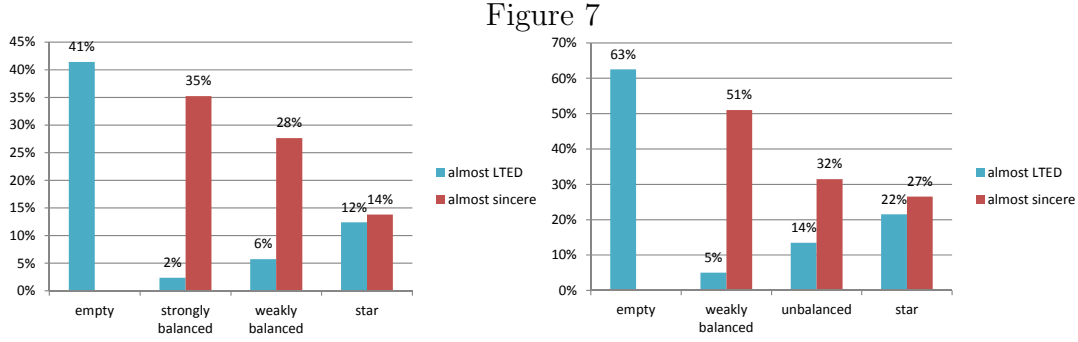


Figure 7: Frequency of behavior consistent with strategy profiles σ^* and $\hat{\sigma}$ by treatment. A strategy profile is “almost” played if at most one agent has chosen a different strategy. The left panel shows results for Study I. The right panel shows results for Study II.

selection (or “strategy profile selection”) to the non-experts.²⁵ As our experimental data reveal, it is indeed the non-experts who strongly condition their behavior on the network structure.

Equilibrium selection. In the equilibrium analysis of our model, we focused on two pure and symmetric strategy profiles that we consider focal, namely on the sincere profile $\hat{\sigma}$ and the “let the experts decide” profile σ^* . Hence, the question arises how often these two strategy profiles are indeed played in the lab, both in general and depending on the network structure.

Figure 7 shows the frequency with which groups play either “let the experts decide” σ^* or sincere $\hat{\sigma}$. We consider a group as *playing almost a strategy profile* if at most one of the nine respectively seven subjects has chosen a different strategy.²⁶ In the empty network, in which $\hat{\sigma}$ cannot be played, we find the highest level of coordination on σ^* . Considering the networks in which both profiles are possible to play, a decrease in network balancedness leads to a drop in the frequency with which groups coordinate (almost) on the sincere strategy profile $\hat{\sigma}$ and to a sizable increase in the frequency with which groups coordinate (almost) on the “let the experts decide” strategy profile σ^* . Fisher exact tests reveal that – apart from the comparison between the strongly and weakly balanced networks in Study I and the unbalanced and star networks in Study II – these differences are significant (Tables 8 and 9). Hence, we find support for the comparative statics of our theory on the group level, too.

Result 2. *In the (strongly and weakly) balanced networks, groups coordinate mostly on the sincere strategy profile $\hat{\sigma}$. With decreasing balancedness of the network, groups coordinate less often on $\hat{\sigma}$ and more often on the “let the experts decide” equilibrium σ^* . Coordination on σ^* is highest in the empty network. Equilibrium selection in favor of σ^* is mainly driven by non-experts who do not follow their message but also by some experts who send an empty message.*

²⁵Another reason might be lying aversion which is common in lab experiments. Not sending a message or sending a message that contradicts the own signal might “feel like” lying.

²⁶Recall that every group in Study I consists of nine real subjects, while every group in Study II consists of seven real subjects and four computerized partisans. The partisans play according to σ^* and $\hat{\sigma}$ by default.

Hence, we find that the comparative-static predictions of the theory are well supported by our experimental findings. Before we proceed to our results on the efficiency of information aggregation, a few remarks on uninformed voting are in order.

Uninformed voting. Non-experts who receive no message, either because they are in the empty network or because their sender chose the empty message, are uninformed. In most of these cases the uninformed non-experts abstain, but in a substantial fraction of around 30% of cases there is a vote by the uninformed non-experts, as can be seen from Table 2. This behavior seems independent of the network structure. To explore individual heterogeneity in uninformed voting the histograms in Figure 8 depict the frequency of voting actions as a fraction of an individual’s incidences of being uninformed. The distribution of individual uninformed voting is clearly U-shaped with two dominant categories: Around 50% of the participants never vote when uninformed, while there are almost 20% of the participants who always vote when uninformed.

This finding is in line with the literature, since positive rates of uninformed voting are found in all experiments on jury voting. Since uninformed votes are no better than flips of a coin, they have large detrimental effects on informational efficiency, well documented in the literature.²⁷ In our experiment, it is the empty network in which all non-experts, trivially, receive no message; hence, if they participate in the vote, this necessarily implies uninformed voting. Consequently, the absolute number of uninformed votes is much higher in the empty network than in the other networks. Thus, the possibility to communicate may serve informational efficiency by reducing the extent of uninformed voting. However, there might also be detrimental effects of communication as we will see next.

3.3.2 Efficiency

Informational Efficiency. Informational efficiency is the higher the more often the signal received by the majority of experts determines the voting outcome. Figure 9 displays the degree of informational efficiency of voting outcomes across networks. As is easy to see, in both experiments the star network performs worst in terms of informational efficiency. Moreover, informational efficiency seems to be decreasing in balancedness of the network structure.

To test whether differences in informational efficiency across networks are significant, we create the variable *efficiency* that takes the value -1 if the voting outcome matches the signal received by a minority of experts (minority signal), the value 0 if a tie occurs, and the value 1 if the voting outcome matches the signal received by the majority of experts (majority signal). Fisher exact tests reveal that the star network exhibits significantly less informational efficiency than the weakly balanced and the empty network in Study II, while the null hypothesis cannot be rejected in Study I. Other differences are not significant (except between the empty and the unbalanced network in Study II). Note that efficiency is also heavily affected by

²⁷Großer and Seebauer (2013) find a 30% rate of uninformed voting. Elbittar et al. (2014) even find that 60% of the uninformed vote.

Figure 8

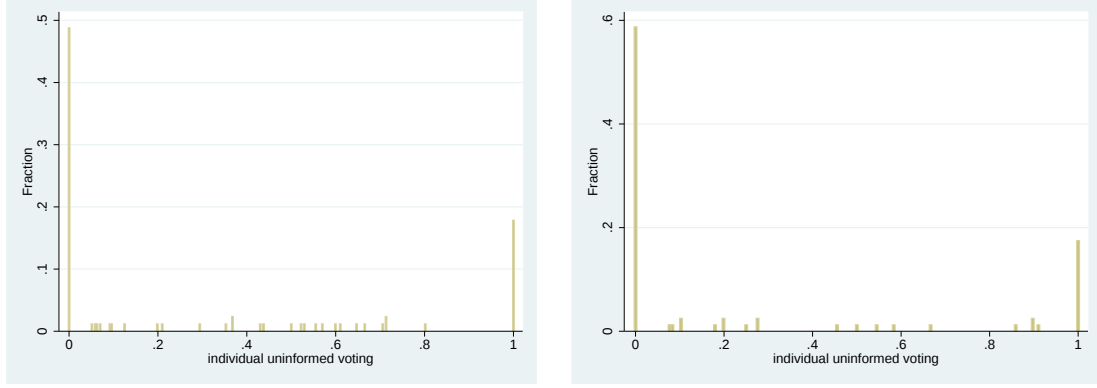


Figure 8: Histogram of individual uninformed voting. For each participant the variable ‘individual uninformed voting’ counts the number of votes (for A or B) as a fraction of the number of instances where the individual is uninformed. For each non-expert this occurs ten times in the empty treatment and it also occurs in the other treatments when an empty message is received. The left panel displays results for Study I. The right panel displays results for Study II. The size of the bar shows the fraction of participants in percent.

signal distributions. If, for instance, the five experts in Study I, or the three experts in Study II, happen to receive the same signal, say A , then it is easier to implement the majority signal A than when there are signals for both A and B , where voting errors are more likely to impair informational efficiency. We call a signal distribution of the form “5:0” (“3:0”) uniform in Study I (II), a signal distribution of the form “3:2” (“2:1”) non-uniform in Study I (II), and a signal distribution of the form “4:1” almost uniform. Controlling for the signal distribution reduces the noise in the analysis of efficiency. Using ordered logit models, we regress *efficiency* on the network type, controlling for the signal distribution. Results are displayed in Table 11. We find again that informational efficiency is lower in the star network than in the empty network in Study II. Additionally, there is some evidence for the same effect in Study I. There is also weak evidence that the unbalanced network is less efficient than the empty network. Moreover, in Study II the star network is also less efficient than the weakly balanced network.²⁸

Result 3. *Informational efficiency is significantly lower in the star network, compared to the empty network (at least in the presence of partisans). There is also weak evidence that the unbalanced network exhibits lower informational efficiency than the empty network and evidence that the star network exhibits lower informational efficiency than the weakly balanced network in the presence of partisans.*

The superiority of the empty network compared to the unbalanced networks is so striking because any strategy profile that is possible to play in the empty network is also feasible in these unbalanced networks. Providing participants with the possibility to communicate can hence have a detrimental effect on their voting outcome.

²⁸This we do not find in Study I probably because one of the differences in behavior between the two experiments is that in Study I several senders in the star network choose the empty message, which mitigates the issue of unbalanced communication.

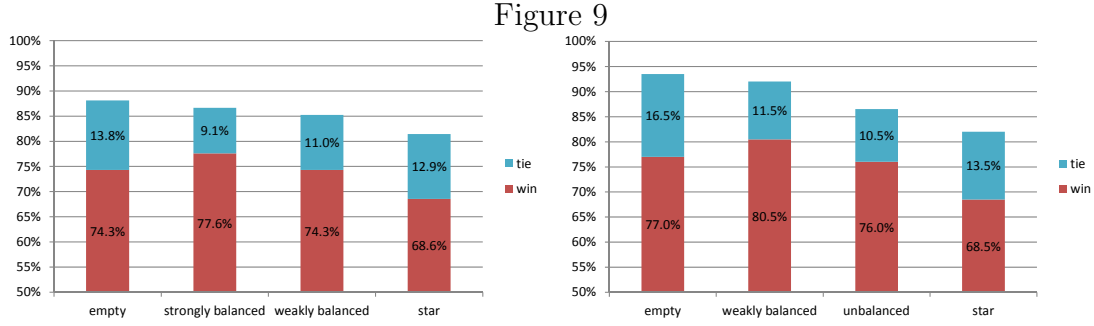


Figure 9: Frequency of informationally efficient group decisions by treatment. Left panel displays results for Study I. Right panel displays results for Study II. ‘Win’ means that the outcome of voting is the majority signal. ‘Tie’ means that there were as many votes for A as for B such that the outcome is correct with probability one half.

Economic Efficiency. To test whether the low informational efficiency in the star network, and probably also in the unbalanced network, affects subjects in an economically meaningful way, we compute the expected payoff EP for each group in each round. If the group decision matches the true state, each member of the group earns 100 points. Hence, the variable EP coincides with the likelihood (in percentage points) of a correct collective decision, given all signals in the group. For instance in Study II, if four experts have received signal A and one expert B and the outcome of the majority vote is A , then $EP = \frac{p^4(1-p)}{p^4(1-p) + (1-p)^4p} * 100$ which is approximately 77.14 for $p = 0.8$.²⁹ Computing EP by network type yields on average 61 (73) points in the star network in Study I (II) and on average 64 (79) points in the other networks in Study I (II), as displayed in Table 12.³⁰

Recall that when not controlling for the distribution of signals, there is additional noise because some treatments might happen to exhibit uniform signals and hence higher expected payoffs more often than others. We test for significant differences using OLS regressions and control for uniformity of signals (Table 13). The findings are analogous to those of Result 3: The inefficiency of the unbalanced networks, in particular of the star network, is confirmed.

Result 4. *Expected payoffs are significantly lower in the star network, compared to the empty network. There is also evidence that the unbalanced networks (including the star) exhibit lower expected payoffs than both the empty network and the weakly balanced network.*

Result 4 consists of two separate findings. The comparison among the networks in which communication is possible shows that an unbalanced communication structure

²⁹If we consider reasonable values of EP to lie between the EP of a dictator who is randomly chosen from M and the EP of an efficient strategy profile, then the range for Study I is [60, 68.3] and the range for Study II is [62.9, 89.6].

³⁰Table 12 also displays the actual number of correct group decisions, which is a less reliable measure of economic efficiency than EP due to the noise induced by imperfect signals. As revealed by t -tests (not in the appendix) the empirical values of EP are significantly below the EP of an efficient strategy profile, except for the case of a uniform signal in Study I, i.e., a signal distribution of the form “5:0,” which virtually always leads to the efficient majority decision.

can be detrimental to efficiency. The comparison of the unbalanced networks with the empty network, where communication is precluded, shows that communication itself can be detrimental to efficiency, confirming Result 3 above.

Avoidability of inefficiency. Finally, we consider only the inefficient group decisions and ask how many deviations would have been necessary in order to induce the efficient outcome. For this purpose, Table 14 reports how many more votes the minority signal received, compared to the majority signal, when the former determined the voting outcome or when a tie occurred. On average we have a vote difference of 0.68 (1.14) in Study I (II), reflecting that most inefficient outcomes are close calls such as ties (where the vote difference is zero) or wins of the minority signal by one vote (where the vote difference is one). We compare this number to the number of experts and the number of non-experts who voted for the minority signal to see who could have prevented the inefficiency. In the non-empty networks, there are on average roughly two non-experts who voted for the minority signal. If they abstained, the efficient outcome would have been reached in most of the cases. In the empty network, inefficiency frequently means that a tie has been reached. As there is on average roughly one non-expert who, without having any information, voted for the minority signal, we can conclude that also in this network structure inefficiency could have been avoided by more abstention of the non-experts. This observation indicates that there are two sources of inefficiency on the side of the non-experts: First, uninformed voting when communication is missing; and second, following too powerful leaders under unbalanced communication.

To summarize, it appears that a strong decrease in balancedness, i.e., a sizable shift of audience from some senders to one other (or a few others), impairs efficient information aggregation and therefore also voters' welfare. Hence, although we find evidence in favor of the comparative statics of our theory and our subjects do switch from sincere voting to the "let the experts decide" equilibrium if network balancedness decreases, this switching behavior is not pronounced enough to prevent detrimental effects of unbalanced communication on informational efficiency. If instead, preplay communication is prohibited altogether, voters can indeed be better off.

4 Extension: Overlapping Audiences

We have so far assumed that experts' audiences do not overlap or, equivalently, that each non-expert listens to at most one expert. In this section we relax this assumption, while keeping all other aspects of the model as they are defined in Section 2. In particular, the network structure g is now only assumed to be bipartite, without any further restrictions. In this more general set-up the definition of the sincere strategy profile $\hat{\sigma}$ is extended as follows: Each non-expert votes for the message A or B that he has received more often; if both messages have been received equally often or if there is no message at all, he abstains. As before, each expert communicates and votes her signal. The definition of the "let the experts decide" strategy profile σ^* need not be extended since the non-experts abstain.

Of our three theoretical results, Propositions 1 - 3, the first and the last trivially extend. Hence, also in the more general set-up, there always exists an equilibrium that is efficient, and there can be equilibria (involving sincere information transmission) that are not efficient. The extension of Proposition 2, which provides a necessary and a sufficient condition for the sincere strategy profile $\hat{\sigma}$ to be an equilibrium is now addressed by using the following definitions. For a set of experts $M' \subseteq M$, define the partition of non-experts $N = \{N^+, N^0, N^-\}$ such that all $i \in N^+$ (respectively all $i \in N^-$) have strictly more (respectively strictly less) links into the set M' than into the set $M \setminus M'$ and denote by n^+ and n^- the sizes of the corresponding sets. Moreover, let $M(i)$ be the set of experts that non-expert $i \in N$ is linked to.

Proposition 4. *Let $m = |M| \geq 5$, and let m be odd. Let the number of links $l := \sum_{i=1}^m d_i$ be even. In the generalized model with g bipartite the following holds. The sincere strategy profile $\hat{\sigma}$ is an equilibrium if (a) for every $M' \subseteq M$ of size $m' = \frac{m-1}{2}$, we have $n^+ \leq n^-$. Let, additionally, the degree of each non-expert be odd and larger than zero. Then $\hat{\sigma}$ is an equilibrium only if (b) $\forall i \in N$, there does not exist a $M' \subseteq M(i)$ such that $\forall M'' \subseteq M \setminus M(i)$ with $m' + m'' + n^+(M' \cup M'') = \frac{m+n+1}{2}$ (and at least one such M'' exists), we have $m' + m'' < \frac{m}{2}$. The sincere strategy profile $\hat{\sigma}$ is efficient if and only if condition (a) is satisfied.*

The sufficient condition (a) is a generalization of strong balancedness and again coincides with both informational efficiency and representativeness of $\hat{\sigma}$ (cf. Lemma B.1). It says that for any largest minority of experts M' the number of non-experts who follow this minority must be smaller than the number of non-experts who follow the complementary set of experts (a smallest majority).

The necessary condition (b) addresses the incentives of a non-expert to follow the message he received most often. A violation of this condition illustrates its interpretation. Suppose there is a non-expert who observes a set of experts M' sending the same message, say A . If for any additional set of experts whose votes for A would render i pivotal (call this set M''), it holds that a majority of experts has received signal B , voting for A is not a best response. More generally, let a non-expert $i \in N$ observe some messages and deduce under $\hat{\sigma}$ that at least half of all non-experts follow his majority message (i.e., the message he has received more often). Then he is “cursed,” i.e., given that i can be pivotal, $\hat{\sigma}_i$ is not a best response to $\hat{\sigma}_{-i}$. The reasoning is trivial: Since at least half of all non-experts follow i ’s majority message, i is only pivotal if at least half of the experts vote for the opposite. Thus, i ’s majority message is the minority signal whenever i is pivotal.

With overlapping audiences, we can not only model private communication but also public communication. Communication is fully public if the network g is complete bipartite, i.e., every expert is linked to every non-expert. In that case, the sincere strategy profile $\hat{\sigma}$ is efficient and an equilibrium. In this *deliberation equilibrium* the majority signal determines votes unanimously (and other voting rules than the majority rule would also admit a similar equilibrium, cf. Gerardi and Yariv, 2007). More generally, in every network g , in which a non-empty subset N' of non-experts is linked to all experts, there are efficient equilibria in which the members of N' vote for the majority signal. Besides the extreme case of fully public communication, in which $N' = N$, there is also an extreme case, in which $N' = \{i\}$ is a

singleton. In the latter the decision is fully delegated to one non-expert who simply implements the majority signal.

Finally, note that the information transmission network g^* under some strategy profile σ need not coincide with the exogenous network g , but can be any subnetwork ($g^* \subseteq g$) of it, which uses some but not necessarily all of the given communication channels (cf. Appendix C.1). For instance, any network g that contains a subnetwork $g' \subseteq g$ which satisfies condition (a) of Proposition 4 admits an efficient equilibrium by using the subnetwork as communication network, i.e., $g^* = g'$. More generally, for every network g that admits an equilibrium σ , every supernet $g' \supseteq g$, that contains all links of g but potentially many more links, also admits an equilibrium which is outcome equivalent to σ . Our model extensions admits denser networks g and hence gives rise to many more information transmission networks $g^* \subseteq g$ than our baseline model, which was restricted to private communication. As a consequence, coordination on an efficient equilibrium might become even harder than in the baseline model, which was tested in the lab experiment.

5 Conclusion

Our experimental evidence supports the comparative-static predictions of our theory with respect to individual and collective voting behavior, but not with respect to informational efficiency. While experts mostly play the sincere strategy, non-experts are highly sensitive to the network structure. The more unbalanced the network, the more averse are the non-experts linked to the expert with the highest degree to “follow” her by voting in line with her message, and the more they tend to abstain. Put differently, non-experts linked to a powerful expert play the less often sincerely and the more often strategically in networks with an unbalanced communication structure. Similarly, groups coordinate more often on the “let the experts decide” equilibrium and less often on the sincere strategy profile if network balancedness decreases. Nonetheless, this tendency is insufficient to compensate the negative effects exerted by overly powerful experts in very unbalanced networks, like the star network. Hence, it is still the empty network in which coordination on the “let the experts decide” equilibrium works best. However, the empty network opens the door much wider for uninformed voting than the other networks and does therefore not exhibit a higher level of informational efficiency than do networks that are balanced.

In our model, efficiency of communication networks depends crucially on the balancedness of the network structure, which translates into the distribution of power among the experts. It should be noticed that the efficiency of strongly balanced networks, respectively the inefficiency of unbalanced networks, is not due to the inequality of the experts’ power per se, but due to the inequality of the experts’ power combined with the homogeneity of their expertise. If we generalize our model such that every expert j has an idiosyncratic signal precision p_j in the interval $(\frac{1}{2}, 1)$, then sincere voting is efficient whenever the degree of each expert is (roughly) proportional to $\log(\frac{p_j}{1-p_j}) - 1$ (see, e.g., Shapley & Grofman 1984, Theorem II).³¹ With

³¹For instance, in Example 2 sincere behavior $\hat{\sigma}$ would be efficient if signal precisions were, e.g., $(p_1, \dots, p_5) = (.9, .6, .6, .6, .6)$. Similarly, in Example 3, sincere behavior would be efficient if, e.g.,

our experimental design we purposefully keep expertise constant among experts to observe *unbalanced power* directly in the network structure. Moreover, the assumption that non-experts do not receive a signal is based on the insight that if the signal quality of some agents is too low, then their signal should be ignored. For instance, in an example with five experts with signal quality $p = 0.9$ and four non-experts with signal quality $q = 0.55$, the efficient strategy profiles always implement the signal that has been received by a majority of experts, ignoring the non-experts' signals.

We have analyzed preplay communication in a voting game of common interest. In contrast to public communication, where information aggregation occurs in the communication stage (Gerardi and Yariv, 2007; [Goeree and Yariv, 2011](#)), we have studied private communication, which only admits information aggregation in the voting stage. Both scenarios can be considered as extreme cases of more general communication structures, which we addressed in an extension. Our analysis seems to be the natural first step toward understanding the effects of prevote communication in even more general social networks.

signal precisions were $(p_1, \dots, p_5) = (.9, .9, .6, .6, .6)$. In those cases, an expert's power is justified by her expertise.

A Appendix: Tables

Table 1a. Observations

treatment	groups	experts	non-experts	senders	receivers
empty	210	1,050	840	0	0
strongly balanced	210	1,050	840	840	840
weakly balanced	210	1,050	840	420	840
star	210	1,050	840	210	840
Total	840	4,200	3,360	1,470	2,520

Table 1a: Number of observations in Study I. Senders are experts who are in a network position with an audience. Non-experts are receivers if they are linked to a sender.

Table 1b. Observations

treatment	groups	experts	non-experts	senders	receivers
empty	200	600	800	0	0
weakly balanced	200	600	800	347	800
unbalanced	200	600	800	178	800
star	200	600	800	83	800
Total	800	2,400	3,200	608	2,400

Table 1b: Number of observations in Study II. Senders are experts who are in a network position with an audience. The number of partisan senders is not displayed. Non-experts are receivers if they are linked to a sender (expert or partisan).

Table 2a. Behavior of non-experts

	vote message	vote opposite	vote uninformed	sincere
empty ($N = 840$)	- -	- -	265 31.6%	575 68.5%
s. balanced ($N = 840$)	577 79.7%	52 7.2%	29 25.0%	664 79.1%
w. balanced ($N = 840$)	480 72.5%	37 5.6%	49 27.5%	609 72.5%
star ($N = 840$)	286 52.2%	66 12.0%	108 37.0%	470 56.0%
Total ($N = 3,360$)	1,343 69.4%	155 8.0%	451 31.6%	2,318 69.0%

Table 2a: Behavior of non-experts by treatment in Study I. In the empty network all non-experts are uninformed. In the other networks this happens only if an expert sender chose the empty message. The action ‘vote message’ means that A (B) is voted after message A (B) has been received. In addition to the displayed categories ‘vote message’ and ‘vote opposite’ non-experts who received message A or B could abstain. In addition to the displayed category ‘vote uninformed’ non-experts who received an empty message could abstain. Non-experts with no message or an empty message are sincere if they abstain. Non-experts with message A (B) are sincere if they vote A (B).

Table 2b. Behavior of non-experts

	vote message	vote opposite	vote uninformed	sincere
empty ($N = 800$)	- -	- -	220 27.5%	580 72.5%
weakly balanced ($N = 800$)	540 69.5%	37 4.8%	6 26.1%	557 69.6%
unbalanced ($N = 800$)	417 54.3%	61 7.9%	11 34.4%	438 54.8%
<i>position 1-3</i> ($N = 600$)	278 48.3%	52 9.0%	9 37.5%	293 48.8%
<i>position 4</i> ($N = 200$)	139 72.4%	9 4.7%	2 25.0%	145 72.5%
star ($N = 800$)	360 46.4%	59 7.6%	7 29.2%	377 47.1%
Total ($N = 3,200$)	1,317 56.7%	157 6.76%	244 27.8%	1,952 61.0%

Table 2b: Behavior of non-experts by treatment (and position) in Study II. The network positions in the unbalanced network refer to Figure 3. In the empty network all non-experts are uninformed. In the other networks this happens only in 79 cases, where an expert sender chose the empty message. The action ‘vote message’ means that A (B) is voted after message A (B) has been received. In addition to the displayed categories ‘vote message’ and ‘vote opposite’ non-experts who received message A or B could abstain. In addition to the displayed category ‘vote uninformed’ non-experts who received an empty message could abstain. Non-experts with no message or an empty message are sincere if they abstain. Non-experts with message A (B) are sincere if they vote A (B).

Table 3a. Dependent variable: Following of non-experts

Variable	Logit 1		Logit 2	
	Coefficient	(Std. Err.)	Coefficient	(Std. Err.)
strongly balanced	0.398*	(0.215)	0.358**	(0.174)
star	-0.882***	(0.181)	-0.730***	(0.139)
Intercept	0.970***	(0.193)	0.969***	(0.152)
N	1,934		2,520	
Log-likelihood	-1133.96		-1501.53	
Wald $\chi^2_{(2)}$	38.48		45.48	
p -value Wald test	0.000		0.000	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3a: Estimation results for Study I: Logistic regression with decision to follow message as dependent variable. Robust standard errors in parentheses adjusted for subjects. Baseline category is the weakly balanced network. Model 1 restricts attention to non-experts who received message A or B . Model 2 also considers non-experts who received an empty message, for which following means abstention. Following coincides with sincere behavior of non-experts.

Table 3b. Dependent variable: Following of non-experts

Variable	Logit 1		Logit 2	
	Coefficient	(Std. Err.)	Coefficient	(Std. Err.)
unbalanced	-0.651***	(0.170)	-0.639***	(0.164)
star	-0.968***	(0.193)	-0.945***	(0.186)
Intercept	0.824***	(0.200)	0.830***	(0.194)
N	2,321		2,400	
Log-likelihood	-1543.26		-1595.30	
Wald $\chi^2_{(2)}$	25.61		25.91	
p -value Wald test	0.000		0.000	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3b: Estimation results for Study II: Logistic regression with decision to follow message as dependent variable. Robust standard errors in parentheses adjusted for subjects. Baseline category is the weakly balanced network. Model 1 restricts attention to non-experts who received message A or B . Model 2 also considers non-experts who received an empty message, for which following means abstention. Following coincides with sincere behavior of non-experts.

Table 4a. Individual sincere behavior of non-experts by position

	never	always	s. balanced	w. balanced	star
s. balanced	4.8%	57.1%		0.127	0.000
w. balanced	8.33%	46.43%			0.000
star	23.8%	29.8%			
<i>empty</i>	<i>19.1%</i>	<i>54.8%</i>	<i>0.033</i>	<i>0.545</i>	<i>0.032</i>
s. balanced	1.2%	51.2%		0.008	0.000
w. balanced	0.0%	31.0%			0.000
star	1.2%	16.7%			

Table 4a: Individual behavior of non-experts by position in Study I: for each individual in each network position (she is in) there is a variable capturing the frequency of sincere actions. The network positions refer to the upper panel of Figure 3. Column 2 and 3 report the fraction of participants who *never* respectively *always* chose the sincere strategy in the given position. The first block restricts attention to instances in which a non-empty message is received and thus reports on following of non-empty vote recommendations. The second block considers all ten decisions of each individual in each positions. In the empty network a non-expert is always uninformed. Columns 4-6 of the table show the p -values of Wilcoxon matched-pairs signed-ranks test.

Table 4b. Individual sincere behavior of non-experts by position

	never	always	empty	w. balanced	unbalanced	star
w. balanced	15.0%	46.3%				0.000
unbalanced <i>pos. 4</i>	20.3%	60.8%		0.855		0.000
unbalanced <i>pos. 1-3</i>	33.8%	30.0%		0.000	0.001 ^a	0.533
star	32.5%	25.0%				
<i>empty</i>	<i>17.5%</i>	<i>60.0%</i>		<i>0.572</i>		<i>0.001</i>
w. balanced	11.3%	43.8%				0.000
unbalanced <i>pos. 4</i>	17.6%	59.5%	0.873	0.964		0.000
unbalanced <i>pos. 1-3</i>	22.5%	25.0%	0.003	0.000	0.001 ^a	0.444
star	21.3%	18.8%				

Table 4b: Individual behavior of non-experts by position in Study II: for each individual in each network position (she is in) there is a variable capturing the frequency of sincere actions. The network positions refer to the lower panel of Figure 3. Column 2 and 3 report the fraction of participants who *never* respectively *always* chose the sincere strategy in the given position. The first block restricts attention to instances in which a non-empty message is received and thus reports on following of non-empty vote recommendations. The second block considers all ten decisions of each individual in each positions. In the empty network a non-expert is always uninformed. Columns 4-6 of the table show the p -values of Wilcoxon matched-pairs signed-ranks test. Note *a*: This is the comparison between non-experts in network positions 1-3 and network position 2 in the unbalanced treatment.

Table 5a. Behavior of experts

	vote signal	vote opposite	send signal	send opposite	sincere
empty ($N = 1,050$)	919 87.5%	62 5.9 %	- -	- -	<i>919</i> <i>87.5%</i>
strongly balanced ($N = 1,050$)	884 84.2%	75 7.1%	671 79.9%	53 6.3%	798 76.0%
weakly balanced ($N = 1,050$)	878 83.6%	74 7.1%	301 71.7%	30 7.1%	803 76.5%
star ($N = 1,050$)	854 81.3%	84 8.0%	128 61.0%	9 4.3%	794 75.6%
Total ($N = 4,200$)	3,535 84.2%	295 7.0%	1,100 74.8%	92 6.3 %	3,314 78.9%

Table 5a: Behavior of experts by treatment in Study I. The action ‘vote (send) opposite’ means vote (send message) A when signal is B and vice versa. In addition to the displayed categories ‘vote signal’ and ‘vote opposite’ experts could abstain. In addition to the displayed categories ‘send signal’ and ‘send opposite’ experts could send an empty message. Experts without an audience are sincere if they vote their signal. Experts with an audience are sincere if they vote their signal and also send it.

Table 5b. Behavior of experts

	vote signal	vote opposite	send signal	send opposite	sincere
empty ($N = 600$)	560 93.3%	21 3.5%	- -	- -	<i>560</i> <i>93.3%</i>
weakly balanced ($N = 600$)	550 91.7%	31 5.2%	309 89.1%	15 4.3%	530 88.3%
unbalanced ($N = 600$)	552 92.0%	22 3.7%	158 88.8%	4 2.3%	534 89.0%
star ($N = 600$)	556 92.7%	27 4.5%	76 91.6%	1 1.2%	550 91.7%
Total ($N = 2,400$)	2,218 92.4%	101 4.2%	543 89.3%	20 3.3%	2,174 90.6%

Table 5b: Behavior of experts by treatment in Study II. The action ‘vote (send) opposite’ means vote (send message) A when signal is B and vice versa. In addition to the displayed categories ‘vote signal’ and ‘vote opposite’ experts could abstain. In addition to the displayed categories ‘send signal’ and ‘send opposite’ experts could send an empty message. Experts without an audience are sincere if they vote their signal. Experts with an audience are sincere if they vote their signal and also send it.

Table 6a. Sincere Senders

Variable	Logit 1: Send Signal		Logit 2: Sincere	
	Coefficient	(Std. Err.)	Coefficient	(Std. Err.)
strongly balanced	0.451***	(0.166)	0.505***	(0.159)
star	-0.483**	(0.200)	-0.486***	(0.186)
Intercept	0.928***	(0.161)	0.619***	(0.159)
N	1,470		1,470	
Log-likelihood	-812.55		-884.94	
Wald $\chi^2_{(2)}$	15.68		20.39	
p -value Wald test	0.000		0.000	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6a: Estimation results for Study I: Logistic regression sincere senders by treatment. Senders are experts with at least one link. Dependent variable in Model 1 is ‘send signal,’ which is 1 if the expert’s message equals her signal (and zero otherwise). Dependent variable in Model 2 is sincere behavior, which equals 1 if sender both sends and votes her signal. Robust standard errors in parentheses adjusted for subjects. Baseline category is the weakly balanced network.

Table 6b. Sincere Senders

Variable	Logit 1: Send Signal		Logit 2: Sincere	
	Coefficient	(Std. Err.)	Coefficient	(Std. Err.)
unbalanced	-0.029	(0.286)	0.080	(0.293)
star	0.289	(0.341)	0.506	(0.359)
Intercept	2.096***	(0.264)	1.878***	(0.253)
N	608		608	
Log-likelihood	-206.44		-226.34	
Wald $\chi^2_{(2)}$	1.03		2.27	
p -value Wald test	0.598		0.322	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6b: Estimation results for Study II: Logistic regression sincere senders by treatment. Senders are experts with at least one link. Dependent variable in Model 1 is ‘send signal,’ which is 1 if the expert’s message equals her signal (and zero otherwise). Dependent variable in Model 2 is sincere behavior, which equals 1 if sender both sends and votes her signal. Robust standard errors in parentheses adjusted for subjects. Baseline category is the weakly balanced network. Observe that models are not well-specified according to Wald test.

Table 7a. Individual sincere behavior of experts by position

	never	always	s. balanced	w. balanced	star
empty: <i>pos. 1-5</i>	1.9%	59.1%	0.161	0.450	0.000
s. balanced: <i>pos. 5</i>	12.6%	70.5%		0.353	0.715
w. balanced: <i>pos. 3-5</i>	2.9%	61.9%			0.047
star: <i>pos. 2-5</i>	1.9%	52.4%			
s. balanced: <i>pos. 1-4</i>	4.8%	49.5%		0.039	0.003
w. balanced: <i>pos. 1-2</i>	12.5%	43.3%			0.085
star: <i>pos. 1</i>	31.6%	43.2%			

Table 7a: Individual behavior of experts by position in Study I: for each individual in each network position (she is in) there is a variable capturing the frequency of sincere actions. The network positions refer to the upper panel of Figure 3. Column 2 and 3 report the fraction of participants who *never* respectively *always* chose the sincere strategy in the given position. Non-experts are ten times in each position. Experts are at most ten times in each position. Columns 4-6 of the table show the p -values of Wilcoxon matched-pairs signed-ranks test. The first block compares experts who are not senders across treatments. The second block compares experts who are senders across treatments.

Table 7b. Individual sincere behavior of experts by position

	never	always	empty	w. balanced	unbalanced	star
empty <i>pos. 1-7</i>	0.0%	73.3%		0.755	0.157	0.485
w. balanced <i>pos. 5-7</i>	1.7%	78.3%			0.142	0.629
unbalanced <i>pos. 3-7</i>	0.0%	73.3%				0.026
star <i>pos. 2-7</i>	0.0%	76.7%				
w. balanced <i>pos. 1-4</i>	1.7%	68.3%				0.334
unbalanced <i>pos. 1</i>	11.1%	80.0%		0.914	0.503 ^a	0.954
unbalanced <i>pos. 2</i>	8.7%	87.0%		0.095		0.655
star <i>pos. 1</i>	10.2%	85.7%				

Table 7b: Individual behavior of experts by position in Study II: for each individual in each network position (she is in) there is a variable capturing the frequency of sincere actions. The network positions refer to the lower panel of Figure 3. Column 2 and 3 report the fraction of participants who *never* respectively *always* chose the sincere strategy in the given position. Participants are at most ten times in each position. Columns 4-6 of the table show the p -values of Wilcoxon matched-pairs signed-ranks test. The first block compares experts who are not senders across treatments. The second block compares experts who are senders across treatments. Note *a*: This is the comparison between experts in network position 1 and network position 2 in the unbalanced treatment.

Table 8a. Fisher exact test on almost σ^*

	strongly balanced	weakly balanced	star
empty	0.000	0.000	0.000
strongly balanced		0.135	0.000
weakly balanced			0.026

Table 8a: p -values of Fisher exact tests comparing the frequency of the “let the experts decide” strategy profile σ^* between two treatments in Study I. A group plays “almost” σ^* if there is at most one player whose strategy differs from the profile.

Table 8b. Fisher exact test on almost σ^*

	weakly balanced	unbalanced	star
empty	0.000	0.000	0.000
weakly balanced		0.010	0.000
unbalanced			0.048

Table 8b: p -values of Fisher exact tests comparing the frequency of the “let the experts decide” strategy profile σ^* between two treatments in Study II. A group plays “almost” σ^* if there is at most one player whose strategy differs from the profile.

Table 9a. Fisher exact test on almost $\hat{\sigma}$

	weakly balanced	star
strongly balanced	0.115	0.000
weakly balanced		0.001

Table 9a: p -values of Fisher exact tests comparing the frequency of the sincere strategy profile $\hat{\sigma}$ between two treatments (in the empty network $\hat{\sigma}$ cannot be played) in Study I. A group plays “almost” $\hat{\sigma}$ if there is at most one player whose strategy differs from the profile.

Table 9b. Fisher exact test on almost $\hat{\sigma}$

	unbalanced	star
weakly balanced	0.000	0.000
unbalanced		0.321

Table 9b: p -values of Fisher exact tests comparing the frequency of the sincere strategy profile $\hat{\sigma}$ between two treatments (in the empty network $\hat{\sigma}$ cannot be played) in Study II. A group plays “almost” $\hat{\sigma}$ if there is at most one player whose strategy differs from the profile.

Table 10a. Fisher exact tests on efficiency

	strongly balanced	weakly balanced	star
empty	0.299	0.543	0.170
strongly balanced		0.705	0.117
weakly balanced			0.429

Table 10a: p -values of Fisher exact tests comparing efficiency between two treatments in Study I. Efficiency is 1 if majority signal wins, 0 in case of a tie, and -1 if majority signal loses.

Table 10b. Fisher exact tests on efficiency

	weakly balanced	unbalanced	star
empty	0.323	0.022	0.002
weakly balanced		0.219	0.007
unbalanced			0.244

Table 10b: p -values of Fisher exact tests comparing efficiency of two treatments in Study II. Efficiency is 1 if majority signal wins, 0 in case of a tie, and -1 if majority signal loses.

Table 11a. Dependent variable: Efficiency

Variable	ologit 1		ologit 2	
	Coeff.	(Std. Err.)	Coeff.	(Std. Err.)
empty			-0.016	(0.185)
strongly balanced	0.110	(0.265)	0.095	(0.238)
weakly balanced	0.016	(0.185)		
star	-0.236*	(0.141)	-0.252	(0.174)
uniform signal	3.173***	(0.593)	3.173***	(0.593)
almost uniform signal	1.579***	(0.367)	1.579***	(0.367)
Intercept cut 1	-1.296	(0.110)	-1.311	(0.152)
Intercept cut 2	-0.492	(0.121)	-0.508	(0.126)
N	840		840	
Log-likelihood	-580.612		-580.612	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11a: Estimation results for Study I: Ordered logit. Efficiency is 1 if majority signal wins, 0 in case of a tie, and -1 if majority signal loses. Robust standard errors in parentheses adjusted for sessions. Less clusters than parameters simply mean that joint significance (Wald test) cannot be tested. The first model uses the empty network as baseline category. The second model uses the weakly balanced network as baseline category.

Table 11b. Dependent variable: Efficiency

Variable	ologit 1		ologit 2	
	Coeff.	(Std. Err.)	Coeff.	(Std. Err.)
empty			-0.059	(0.140)
weakly balanced	0.059	(0.140)		
unbalanced	-0.276*	(0.164)	-0.335	(0.210)
star	-0.711**	(0.319)	-0.770***	(0.243)
uniform signal	2.027***	(0.135)	2.027***	(0.135)
Intercept cut 1	-1.611	(0.208)	-1.670	(0.251)
Intercept cut 2	-0.572	(0.122)	-0.631	(0.179)
N	800		800	
Log-likelihood	-513.262		-513.262	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11b: Estimation results for Study II: Ordered logit. Efficiency is 1 if majority signal wins, 0 in case of a tie, and -1 if majority signal loses. Robust standard errors in parentheses adjusted for sessions. Less clusters than parameters simply mean that joint significance (Wald test) cannot be tested. The first model uses the empty network as baseline category. The second model uses the weakly balanced network as baseline category.

Table 12a. Expected Payoff EP and Success

treatment	EP	Success
empty	64.2	62.9%
strongly balanced	64.2	65.7%
weakly balanced	63.7	60.5%
star	60.8	60.5%
Total	63.2	62.4%

Table 12a: Expected Payoff EP and Success in Study I. EP can be interpreted as the likelihood in percent that the group decision matches the true state. Success is the fraction of group decisions which were actually correct. If we consider reasonable values of EP to lie between the EP of a dictator who is randomly chosen from M and the EP of an efficient strategy profile, then the reasonable range is [60, 68.3].

Table 12b. Expected Payoff EP and Success

treatment	EP	Success
empty	79.5	70.5%
w.balanced	81.0	81.5%
unbalanced	77.4	78.0%
star	72.6	70.5%
Total	77.6	75.1%

Table 12b: Expected Payoff EP and Success in Study II. EP can be interpreted as the likelihood in percent that the group decision matches the true state. Success is the fraction of group decisions which were actually correct. If we consider reasonable values of EP to lie between the EP of a dictator who is randomly chosen from M and the EP of an efficient strategy profile, then the reasonable range is [62.9, 89.6].

Table 13a. Dependent variable: Expected payoff EP

Variable	OLS 1		OLS 2	
	Coefficient	(Std. Err.)	Coefficient	(Std. Err.)
empty			-0.231	(0.644)
strongly balanced	-0.110	(1.489)	-0.341	(1.196)
weakly balanced	0.231	(0.644)		
star	-1.356*	(0.646)	-1.587*	(0.678)
uniform signal	33.309***	(0.506)	33.309***	(0.506)
almost uniform signal	18.202***	(1.680)	18.202***	(1.680)
Intercept	54.272***	(0.567)	54.503***	(0.424)
N	840		840	
R^2	0.534		0.534	
p -value F-test	0.000		0.000	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13a: Estimation results for Study I: OLS with expected payoff EP as dependent variable. Robust standard errors in parentheses adjusted for sessions. The first model uses the empty network as baseline category. The second model uses the weakly balanced network as baseline category.

Table 13b. Dependent variable: Expected payoff EP

Variable	OLS 1		OLS 2	
	Coefficient	(Std. Err.)	Coefficient	(Std. Err.)
empty			0.754	(0.796)
weakly balanced	-0.754	(0.796)		
unbalanced	-3.528**	(0.997)	-2.773**	(0.915)
star	-7.703*	(2.847)	-6.949**	(2.219)
uniform signal	31.214***	(0.844)	31.214***	(0.844)
Intercept	64.411***	(1.312)	63.656***	(1.625)
N	800		800	
R^2	0.347		0.347	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13b: Estimation results for Study II: OLS with expected payoff EP as dependent variable. Robust standard errors in parentheses adjusted for sessions. The first model uses the empty network as baseline category. The second model uses the weakly balanced network as baseline category.

Table 14a. Avoidability of inefficiency

	vote difference	“wrong” experts	“wrong” non-experts	preventable
empty ($N = 54$)	0.74	2.26	1.11	51.9%
s. balanced ($N = 47$)	1.09	2.19	2.04	72.3%
w. balanced ($N = 54$)	1.24	2.22	1.87	59.3%
star ($N = 66$)	1.41	2.15	2.05	60.6%
Total ($N = 221$)	1.14	2.20	1.77	60.6%

Table 14a: Avoidability of inefficiency in Study I. The variable ‘vote difference’ refers to the absolute difference of the number of votes. A vote difference of, e.g., 2 means that the minority signal has received two more votes than the majority signal; and a vote difference of 0 means that a tie has occurred. The label “wrong” refers to an agent who voted for the minority signal. The table reports the mean of these variables over all inefficient cases, i.e., for all groups where the majority signal did not receive a majority of votes. Column 5 ‘preventable’ reports the fraction of groups that would have avoided an inefficient outcome if all “wrong” non-experts abstained.

Table 14b. Avoidability of inefficiency

	vote difference	“wrong” experts	“wrong” non-experts	preventable
empty ($N = 46$)	0.33	1.09	1.13	76.1%
w. balanced ($N = 39$)	0.56	1.13	2.05	87.2%
unbalanced ($N = 48$)	0.75	0.98	2.06	91.7%
star ($N = 63$)	0.95	0.90	2.30	87.3%
Total ($N = 196$)	0.68	1.01	1.92	85.7%

Table 14b: Extent of inefficiency in Study II. The variable ‘vote difference’ refers to the absolute difference of the number of votes. A vote difference of, e.g., 2 means that the minority signal has received two more votes than the majority signal; and a vote difference of 0 means that a tie has occurred. The label “wrong” refers to an agent who voted for the minority signal. The table reports the mean of these variables over all inefficient cases, i.e., for all groups where the majority signal did not receive a majority of votes. Column 5 ‘preventable’ reports the fraction of groups that would have avoided an inefficient outcome if all “wrong” non-experts abstained.

B Proofs

To prove Prop. 2 we first state a helpful lemma which makes use of the the following definition.

Definition B.1. (*Representation*): For a social network g and a strategy profile σ we say that the agents in M (i.e., the experts) represent the society if the outcome of voting among the agents in M coincides with the outcome of voting in the society $N \cup M$ for any realization of the draws of nature. We call a network g **representative** under strategy profile σ if the agents in M represent the society.

Lemma B.1. Let $m = |M|$ be odd and $m \geq 5$. The following statements about a network g are equivalent:

1. g is such that sincere voting $\hat{\sigma}$ is efficient.
2. g is representative under sincere voting $\hat{\sigma}$.
3. g is strongly balanced.

Proof. Suppose g is such that $\hat{\sigma}$ is efficient. Then for any draw of nature the majority signal must be implemented. Restricting attention to votes within M , indeed for any draw of nature the majority signal receives a majority of votes under $\hat{\sigma}$ since each expert simply votes her signal. Thus, (1.) implies (2.).

To show that (2.) implies (3.) denote the number of links $l := \sum_{j=1}^m d_j$ and let the degree distribution be ordered in decreasing order as in Definition 2. Consider a draw of nature in which the outcome of voting restricted to M is A with one vote more than B . If all experts with signal B happen to be the most powerful experts, the number of votes for B is: $\sum_{j=1}^{\frac{m-1}{2}} (1 + d_j)$. By representativeness, A must be the outcome among all voters. Thus, the number of votes for B must be smaller than $\frac{m+l}{2}$ (which is half of the total number of votes). Strong balancedness follows from a simple rearrangement of this condition:

$$\sum_{j=1}^{\frac{m-1}{2}} (1 + d_j) < \frac{m + l}{2} \quad (\text{B.1})$$

$$d_1 + \sum_{j=2}^{\frac{m-1}{2}} d_j < \frac{1}{2} + \frac{l}{2} \quad (\text{B.2})$$

$$d_1 + \sum_{j=2}^{\frac{m-1}{2}} d_j \leq \frac{l}{2} \quad (\text{B.3})$$

The last inequality holds true because we have a sum of integers on the left-hand side (LHS) (such that “ $+\frac{1}{2}$ ” can be omitted when changing to a weak inequality).

It remains to show that (3.) implies (1.), i.e., in strongly balanced networks the majority signal is always implemented under $\hat{\sigma}$. Without loss of generality let A be the majority signal of some draw of nature. Since all experts communicate their

signal, the number of votes for B is smaller or equal to $\sum_{j=1}^{\frac{m-1}{2}} (1 + d_j)$ (which is the number of votes of the most powerful minority). If g is strongly balanced, this is the minority of votes (see inequality B.1) such that the majority signal A wins. $\square$

Proof of Proposition 2

The efficiency statement in Prop. 2 is the equivalence of statements (1.) and (3.) of Lemma B.1 and has been shown in its proof. The sufficiency of strong balancedness for $\hat{\sigma}$ to be an equilibrium follows from its efficiency. By deviating from this strategy profile, expected utility can only be reduced.

It remains to show that weak balancedness is a necessary condition for $\hat{\sigma}$ to be an equilibrium; or there must be an agent that is never pivotal under $\hat{\sigma}$.

Suppose that all agents can be pivotal under $\hat{\sigma}$. Let i be a non-expert listening to a sender with maximal degree d_1 . If i is pivotal under $\hat{\sigma}$, the number of votes for i 's message, say A , is $\frac{m+l+1}{2}$ such that A wins by one vote (because i can only deviate by abstaining or voting B and recall that m is odd and l is even). A number $d_1 + 1$ of these votes are due to i 's sender. All remaining votes for A can also be partitioned such that each vote corresponds to one agent in M . The maximal number of agents in M for this purpose is attained when the least powerful agents in M (besides i 's sender) vote for A . If even this maximal number of agents in M (who vote for A) is less than or equal to $\frac{m-1}{2}$, then A is the minority signal whenever i is pivotal. This is true if the number of votes under $\hat{\sigma}$ that correspond to i 's sender and the $\frac{m-3}{2}$ "weakest" members of M is already equal or larger than $\frac{m+l+1}{2}$ what is required by pivotality. This is incorporated in the following inequality

$$d_1 + 1 + \sum_{k=\frac{m+5}{2}}^m (d_k + 1) \geq \frac{m + l + 1}{2}, \quad (\text{B.4})$$

which simplifies as follows:

$$d_1 + \sum_{k=\frac{m+5}{2}}^m d_k + \frac{m-1}{2} \geq \frac{l}{2} + \frac{m+1}{2} \quad (\text{B.5})$$

$$d_1 + \sum_{k=\frac{m+5}{2}}^m d_k \geq \frac{l}{2} + 1 \quad (\text{B.6})$$

$$d_1 + \sum_{k=\frac{m+5}{2}}^m d_k > \frac{l}{2}. \quad (\text{B.7})$$

Since these conditions are sufficient for a profitable deviation of i , the converse condition is necessary for $\hat{\sigma}$ to be an equilibrium:

$$d_1 + \sum_{k=\frac{m+5}{2}}^m d_k \leq \frac{l}{2}. \quad (\text{B.8})$$

$\square$

Proof of Corollary 1

We first show that efficiency of $\hat{\sigma}$ is equivalent to equal power of experts in the corresponding weighted majority game (M, v) . A pair of players $j, k \in M$ is called symmetric if $\forall S \subseteq M \setminus \{j, k\}$ we have $v(S \cup \{j\}) = v(S \cup \{k\})$. A pair of players has the same Banzhaf index $\beta_j(v) = \beta_k(v)$, respectively the same Shapley-Shubik index $\phi_j(v) = \phi_k(v)$, if and only if they are symmetric (e.g., Matsui and Matsui, 2000).

Suppose g is strongly balanced or equivalently that $\hat{\sigma}$ is efficient (Lemma B.1). Then, the decision of the group always coincides with the majority signal. For the corresponding weighted majority game this means that a coalition $S \subseteq M$ is winning if and only if $|S| > \frac{m}{2}$. Hence, every pair of players in this game is symmetric. Consequently, all players are equally powerful. (More precisely, $\beta_j(v) = \frac{1}{2^{m-1}} \binom{m-1}{\frac{m-1}{2}}$ and $\phi_j(v) = \frac{1}{m}$ for all $j \in M$.)

Now, suppose that power of each agent is equal, i.e., $\beta_j(v) = \beta_k(v)$ for all $j, k \in M$. Then all pairs of players are symmetric. This is equivalent to the existence of a positive integer k such that $v(S) = 1$ if and only if $|S| \geq k$ (Matsui and Matsui, 2000, Theorem 6). Clearly, in a weighted majority game with an odd number of players and quota one half of all weights, $k = \frac{m+1}{2}$.³² Thus, a coalition S is winning if and only if $|S| \geq \frac{m+1}{2}$, which means that the majority of experts determine the outcome. This corresponds to efficiency of $\hat{\sigma}$ (and to strong balancedness). Hence, $\hat{\sigma}$ is an equilibrium.

It remains to show that $\hat{\sigma}$ is only an equilibrium if (b) the coalition consisting of the most powerful expert and the $\frac{m-3}{2}$ least powerful experts is not winning in (M, v) , or there must be an agent that is never pivotal under $\hat{\sigma}$. There might be multiple ways to rank experts according to power (because several experts can attain the same Banzhaf index or the same Shapley-Shubik index). We show that the statement holds for any of those rankings. In particular, we show (for any ranking of experts according to power) that weak balancedness implies the condition (b) above. The result then follows from Proposition 2.

As in Definition 2, order the degree distribution in decreasing order $(d_1, d_2, \dots, d_m)$ such that $d_j \geq d_{j+1}$ and relabel the experts accordingly $M = \{j_1, j_2, \dots, j_m\}$. Suppose that weak balancedness is satisfied, i.e., $d_1 + \sum_{k=\frac{m+5}{2}}^m d_k \leq \frac{l}{2}$. Adding $\frac{m-1}{2}$ on both sides yields

$$d_1 + 1 + \sum_{k=\frac{m+5}{2}}^m (d_k + 1) \leq \frac{m + l - 1}{2} < \frac{m + l}{2}.$$

Hence, $v(\tilde{M}) = 0$ for $\tilde{M} := \{j_1, j_{\frac{m+5}{2}}, j_{\frac{m+7}{2}}, \dots, j_m\}$.

Now, let $r : M \rightarrow \{1, 2, \dots, m\}$ be some ranking of the experts according to power such that $\beta_j(v) > \beta_k(v)$ implies $r(j) < r(k)$; or likewise, $\phi_j(v) > \phi_k(v)$ implies $r(j) < r(k)$. Let $M' := \{r^{-1}(1), r^{-1}(\frac{m+5}{2}), r^{-1}(\frac{m+7}{2}), \dots, r^{-1}(m)\}$, be the coalition

³²Suppose $k < \frac{m}{2}$ and consider a coalition S of size k . Then $v(S) = 1$ because $|S| \geq k$ and $v(M \setminus S) = 1$ because $|M \setminus S| = m - k \geq k$. Thus, the game is not proper, i.e., there is a coalition S such that $v(S) = 1$ and $v(M \setminus S) = 1$, which is a contradiction in a weighted majority game (with quota one half of all weights). Hence, $k \geq \frac{m}{2}$. Suppose $k > \frac{m+1}{2}$ and consider a coalition S of size $k = \frac{m+1}{2}$. Then $v(S) = 0$ because $|S| < k$ and $v(M \setminus S) = 0$ because $|M \setminus S| = \frac{m-1}{2} < k$. Again, a contradiction. Hence, $k = \frac{m+1}{2}$.

of the most powerful expert and the $\frac{m-3}{2}$ least powerful experts according to the ranking r . We show that weak balancedness, i.e., $v(\tilde{M}) = 0$, implies $v(M') = 0$.³³

If $r^{-1}(1) \notin \tilde{M}$, replace j_1 by $r^{-1}(1)$ in the set $\tilde{M}$ and call the resulting set M'_0 . Since $d_1 \geq d_{r^{-1}(1)}$, $v(\tilde{M}) = 0$ implies $v(M'_0) = 0$. Now, we compare the set

$$M'_0 = \{r^{-1}(1), j_{\frac{m+5}{2}}, j_{\frac{m+7}{2}}, \dots, j_m\}$$

with the set

$$M' = \{r^{-1}(1), r^{-1}(\frac{m+5}{2}), r^{-1}(\frac{m+7}{2}), \dots, r^{-1}(m)\}.$$

First, note that $|M' \setminus M'_0| = |M'_0 \setminus M'|$ and let $t := |M' \setminus M'_0|$. If $t = 0$, the two sets, M' and M'_0 , coincide and we are done. Otherwise, consider some $j \in M'_0 \setminus M'$ and some $k \in M' \setminus M'_0$. $j \in M'_0$ and $k \notin M'_0$ means that $d_k > d_j$, which implies that $\beta_k(v) \geq \beta_j(v)$. On the other hand, $k \in M'$ and $j \notin M'$ means that $r(j) < r(k)$, which implies that $\beta_j(v) \geq \beta_k(v)$. Together, we have $\beta_j(v) = \beta_k(v)$, which means that j and k are symmetric in (M, v) . Replace j by k in the set M'_0 and call the newly formed set M'_1 . If $t = 1$ we are done. Otherwise, take some other $j \in M'_0 \setminus M'$ and some other $k \in M' \setminus M'_0$. Replace j by k in the set M'_0 and call the newly formed set M'_2 . Repeat this procedure t times to receive $M'_t = M'$. Since in each step, we have replaced a player with a symmetric player, the value of the coalition, i.e., whether it is winning or not, has not changed. Hence, $v(M'_0) = v(M'_1) = \dots = v(M'_t) = v(M')$.

Recall that weak balancedness means $v(\tilde{M}) = 0$ and by construction this implies that $v(M'_0) = 0$. In turn, this implies $v(M') = 0$, which is condition (b) of Corollary 1. □

Proof of Proposition 3

We show existence of inefficient strategy profiles with the network introduced in Example 3. This network violates strong balancedness such that by Prop. 2 the sincere strategy profile $\hat{\sigma}$ is inefficient. To demonstrate that $\hat{\sigma}$ is an equilibrium we show that there is no profitable deviation for any player. We distinguish between the non-experts, the experts with degree zero, and the experts with degree two.

Non-experts. Under $\hat{\sigma}$, non-expert $i \in N$ is pivotal if and only if the votes of all others would lead to a tie (4:4) because vote differences of others are even numbers. Moreover, in this example a tie of all others is only reached under $\hat{\sigma}$ if signals of the “other” experts (the ones not linked to i) form a tie as well (2:2). In particular, it must be the case that the expert with an audience has received the same signal as exactly one expert without an audience. Since the “own” expert (the one linked to i) reports truthfully under $\hat{\sigma}$, the message received by i is the majority signal (3:2). Thus, the posterior belief that the received message indicates the correct alternative is above 0.5, even when conditioning on pivotality. Therefore, voting for this alternative leads to higher expected utility than abstaining (which would

³³In fact, the two are equivalent, but this is not necessary to prove the corollary.

lead to an expected utility of 0.5) and to a higher expected utility than voting the opposite. Thus, a non-expert cannot improve upon $\hat{\sigma}_i$, which prescribes to vote the message.

Experts without an audience. Under $\hat{\sigma}$, expert $j \in M$ with degree $d_j = 0$ is pivotal if and only if the votes of all others would lead to a tie (4:4) because vote differences of others are even numbers. In this example, a tie of all others is only reached under $\hat{\sigma}$ if signals of the “other” experts form a tie as well (2:2). (In particular, it must be the case that each signal has been received exactly by one out of two experts with an audience and by one out of two other experts without an audience.) Thus, the own signal is the majority signal (3:2). Now, for the same reason as for non-experts above, voting for this alternative leads to highest expected utility. Hence, there is no profitable deviation from $\hat{\sigma}_j$ for an expert without an audience.

Experts with an audience. Consider an expert $j \in M$ of degree $d_j = 2$. There are 80 ways in which this expert can deviate from the sincere strategy profile $\hat{\sigma}$ since experts with an audience can choose both voting actions and messages as a function of their signal (see proof of Prop. C.5 for why we have 81 strategies). A deviation only affects the outcome if the signal that j has received wins under $\hat{\sigma}$, but not when j deviates. W.l.o.g. assume that expert j has received signal A . Then the outcomes ($\#A : \#B$) that expert j can overturn are 7:2, 6:3, and 5:4 (i.e., $y = 5, 3, 1$). We proceed by showing for each of these outcomes that the probability that A is correct is above 0.5 such that there is no incentive to deviate from $\hat{\sigma}$. The outcome 7:2 with j receiving A is reached under $\hat{\sigma}$ only if signals were 3:2 in favor of A . The same holds true for the outcome 5:4. Thus, overruling these outcomes is decreasing expected utility. Finally, the outcome 6:3 can be based on two situations. Either signals are 4:1 and the other expert with an audience has received signal B (while all experts without an audience have also received signal A); or signals are 2:3 and both experts with an audience have received signal A (while all others have received signal B).

Using the probabilities of these two events, we observe that A is more likely to be true than B , given that j has received signal A and the outcome is 6:3, if and only if the following inequality holds:

$$5p^4(1-p)\frac{4}{5} * \frac{1}{4} + 10p^2(1-p)^3\frac{2}{5} * \frac{1}{4} \geq 5p(1-p)^4\frac{4}{5} * \frac{1}{4} + 10p^3(1-p)^2\frac{2}{5} * \frac{1}{4}.$$

The inequality compares the probability that A is true (when signals are 4:1 and 2:3) on the LHS with the probability that B is true (when signals are 4:1 and 2:3) on the right-hand side, given that j has received signal A and the outcome is 6:3. The inequality simplifies to

$$p^4(1-p) - p^3(1-p)^2 \geq p(1-p)^4 - p^2(1-p)^3,$$

which is true (since the LHS is positive and the RHS is negative for $p > 0.5$). Hence, any outcome that an expert with an audience can overturn in this example is more likely to match the true state than the alternative.

Therefore, there cannot be any profitable deviation from $\hat{\sigma}$. $\square$

Proof of Proposition 4

We first show that $\hat{\sigma}$ is efficient if and only if property (a) is satisfied. Since “efficiency implies equilibrium” (because every player’s expected utility is maximal), this will demonstrate that condition (a) is sufficient for $\hat{\sigma}$ to be an equilibrium. Finally, we turn to the necessary condition (b).

Efficiency *if* (a). We show sufficiency (*if* (a) is satisfied, then $\hat{\sigma}$ is efficient) by demonstrating that for inefficient networks condition (a) is violated.

Suppose $\hat{\sigma}$ is inefficient. Then there is a draw of nature s.t. A is the majority signal, but does not receive more votes than B .

Consider such a draw of nature. Let $\tilde{M}$ be the set of experts who have received signal B and denote its size by $\tilde{m}$. Because A is the majority signal, $\tilde{m} \leq \frac{m-1}{2}$. Let $\tilde{N}$ be the set of non-experts who vote B under this draw of nature and denote its size by $\tilde{n}$. Hence, the number of votes for B is $\tilde{m} + \tilde{n}$. The number of votes for A is $m - \tilde{m}$ (experts) plus the number of non-experts $n^-(\tilde{M})$ who have strictly less links into $\tilde{M}$ than into $M \setminus \tilde{M}$. By assumption B receives at least as many votes as A , i.e.,

$$\tilde{m} + \tilde{n} \geq (m - \tilde{m}) + n^-(\tilde{M}). \quad (\text{B.9})$$

Now, if $\tilde{m} = \frac{m-1}{2}$, let $M' := \tilde{M}$; otherwise add $\frac{m-1}{2} - \tilde{m}$ arbitrary members of $M \setminus \tilde{M}$ to $\tilde{M}$ and call the new set M' . Note that when expanding the set from $\tilde{M}$ to M' all non-experts $i \in \tilde{N}$ who already had more links into $\tilde{M}$ than into the complement also have more links into M' than its complement. Thus, we have $n^+ := n^+(M') \geq n^+(\tilde{M}) = \tilde{n}$. Similarly, we have $n^- := n^-(M') \leq n^-(\tilde{M})$ because M' is a weak superset of $\tilde{M}$. When using these two inequalities together with $\tilde{m} \leq m'$, Eq. B.9 implies

$$m' + n^+ \geq (m - m') + n^-. \quad (\text{B.10})$$

Using $m' = \frac{m-1}{2}$, Eq. B.10 simplifies to

$$\begin{aligned} 2m' + n^+ &\geq m + n^- \\ (m-1) + n^+ &\geq m + n^- \\ n^+ &\geq n^- + 1 \\ n^+ &> n^-, \end{aligned}$$

which is a violation of condition (a). Thus, when $\hat{\sigma}$ is inefficient, condition (a) is violated (which means that if condition (a) is satisfied, $\hat{\sigma}$ must be efficient). Since in an efficient strategy profile any players’ expected utility is maximal, condition (a) implies that $\hat{\sigma}$ is an equilibrium.

Efficiency *only if* (a). We show necessity ($\hat{\sigma}$ is efficient *only if* condition (a) is satisfied) by demonstrating that a violation of condition (a) implies inefficiency.

Suppose that (a) is violated. Then there is a set M' of size $m' = \frac{m-1}{2}$ with $n^+ > n^-$. This implies

$$n^+ > n^- \quad (\text{B.11})$$

$$n^+ + \frac{m-1}{2} > n^- + \frac{m-1}{2} \quad (\text{B.12})$$

$$n^+ + \frac{m-1}{2} \geq n^- + \frac{m-1}{2} + 1 \quad (\text{B.13})$$

$$n^+ + m' \geq n^- + (m - m'). \quad (\text{B.14})$$

Now, consider a draw of nature that gives signal B to expert j if and only if $j \in M'$. Under $\hat{\sigma}$, all experts $j \in M'$ vote for B and all experts $j \in M \setminus M'$ vote for A . Since each non-expert $i \in N^+$ has strictly more links into M' than into $M \setminus M'$, B is i 's majority message. Hence, all non-experts $i \in N^+$ vote for B , while all non-experts $i \in N^-$ vote for A . (The non-experts $i \in N^0$ have either zero links $d_i = 0$ or the same number of links $\frac{d_i}{2}$ into M' as into $M \setminus M'$ and thus abstain.) The number of votes for B is hence $m' + n^+$, i.e., the LHS of Eq. B.14, and the number of A votes is $(m - m') + n^-$, i.e., the RHS of Eq. B.14. By Eq. B.14 alternative B receives at least as many votes as A . However, by assumption $m' = \frac{m-1}{2} < \frac{m}{2}$. Thus, B is the minority signal, but it is implemented with positive probability. This is inefficient. We have shown that a violation of condition (a) implies inefficiency of $\hat{\sigma}$, which proves that if $\hat{\sigma}$ is efficient, then condition (a) must be satisfied.

Equilibrium *only if* (b). Let the degree of each non-expert be odd and larger than zero. Suppose that condition (b) is violated. Then there is a non-expert $i \in N$ and a set of experts $M' \subseteq M(i)$ such that $\forall M'' \subseteq M \setminus M(i)$ with $m' + m'' + n^+(M' \cup M'') = \frac{m+n+1}{2}$, we have $m' + m'' < \frac{m}{2}$.

Consider a draw of nature such that an expert $j \in M(i)$ receives signal A if and only if $j \in M'$. Denote by $M'' \subseteq M \setminus M(i)$ the other experts with signal A . Under $\hat{\sigma}$ all experts and non-experts participate in the vote (since the non-experts have an odd degree by assumption). Non-expert i is hence pivotal if and only if $m' + m'' + n^+(M' \cup M'') = \frac{m+n+1}{2}$. Since for any potential set M'' that renders i pivotal, it holds by assumption that $m' + m'' < \frac{m}{2}$, i.e., i votes for the minority signal under $\hat{\sigma}$ whenever his vote is decisive. By abstaining (or by voting the opposite) in the case of observing exactly experts $j \in M'$ send the same message, non-expert i can improve upon $\hat{\sigma}_i$, given that all others play according to $\hat{\sigma}_{-i}$. □

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Supplementary Online Material

This supplementary online material belongs to the paper “The Swing Voter’s Curse in Social Networks” by Berno Buechel and Lydia Mechtenberg. It consists of the following sections:

C Supplementary Mathematical Appendix

C.1 Equilibrium Analysis of Examples 1, 2, and 3

C.2 A Necessary and Sufficient Condition

C.3 Partisans

D Instructions

C Supplementary Mathematical Appendix

C.1 Equilibrium Analysis of Examples 1, 2, and 3

We define the concept of a *transmission network* $g^* \subseteq g$ as follows: A link g_{ij}^* between non-expert $i \in N$ and expert $j \in M$ exists if and only if j truthfully transmits her signal to i . Truthful transmission requires that the expert sends a message $m_j^* \in \{A, B, \emptyset\}$ whenever her signal is A and sends a different message $m_j^{*'} \in \{A, B, \emptyset\}$, $m_j^{*'} \neq m_j^*$ whenever her signal is B ; and that (2) the posterior belief of the non-expert, conditional on the message received, equals the posterior belief of the expert, conditional on her signal. In equilibrium, (1) implies (2). A transmission network g^* arises on the communication stage on the equilibrium path. Note that different communication strategies support a given g^* , e.g., sending message A after signal A and message B after signal B transmits the same information as sending message B after signal A and message A after signal B . Since we are only interested in the information transmission (and voting behavior) in equilibrium and not in the precise “language” that transmits the information, we will not fully specify the communication strategies but refer to the resulting transmission network instead. Hence, we can drop any explicit reference to the full strategy profiles σ . Let v denote the strategy profile of all players on the voting stage. Then, any type of equilibrium of our examples 1, 2, and 3 can be fully characterized by g^* and v . Note that any two equilibria that are characterized by a given g^* and v are identical with respect to all equilibrium beliefs, voting strategies and outcomes.³⁴

Let $\widetilde{m}_i(s_j) \in \{A, B, \emptyset\}$ denote the meaning that non-expert i ascribes to message m_j^* if $g_{ij}^* = 1$ for some expert j who received signal $s_j \in \{A, B\}$: i believes that the expert’s voting recommendation is $\widetilde{m}_i$, with $\widetilde{m}_i = A$ indicating a recommendation to vote for A , $\widetilde{m}_i = B$ indicating a recommendation to vote for B , and $\widetilde{m}_i = \emptyset$ indicating a recommendation to abstain. Slightly abusing notation, we write

³⁴We do not explicitly specify off-equilibrium beliefs; hence the equilibria of one type may differ in those. However, equating the off-equilibrium belief with the priors for any non-expert who, surprisingly, finds himself uninformed after an expert’s deviation from g^* on the communication stage supports all selected equilibria.

$v_i(\widetilde{m}_i) \in \{A, B, \emptyset\}$ to denote the voting strategy of non-expert i with $g_{ij}^* = 1$ for some j . Analogously, the voting strategy of a non-expert i with $g_{ij}^* = 0$ for all $j \in M$ is denoted by $v_i(\emptyset) \in \{A, B, \emptyset\}$. Moreover, let $\widetilde{s}_l$ denote either signal $s_l \in \{A, B\}$ received by $l \in M$ or the meaning $\widetilde{m}_l$ of the message received by $l \in N$. Then, we write $v_l(\widetilde{s}_l) \in \{A, B, \emptyset\}$ to denote the voting strategy of $l \in M \cup N$.

We now define the following four selection criteria that guide our equilibrium analysis:

1. **Purity:** The equilibrium is in pure strategies.
2. **Symmetry:** Any two experts, as well as any two non-experts, with the same degree in the transmission network apply identical strategies.
3. **Monotonicity:** If $v_i(\widetilde{m}_i') = \widetilde{m}_i$ for some $\widetilde{m}_i' \in \{A, B, \emptyset\}$, then $v_i(\widetilde{m}_i) = \widetilde{m}_i$; and if $\widetilde{m}_i(s_j') = s_j$ for some $s_j' \in \{A, B\}$, then $\widetilde{m}_i(s_j) = s_j$.
4. **Neutrality:** (i) Unbiased voting: Either $v_l(\widetilde{s}_l) = \widetilde{s}_l$ for all $\widetilde{s}_l \in \{A, B\}$ or $v_l(\widetilde{s}_l) \neq \widetilde{s}_l$ for all $\widetilde{s}_l \in \{A, B\}$; and $v_i(\emptyset) = \emptyset$. (ii) Unbiased information transmission: Either $\widetilde{m}_i(s_j) = s_j$ for all $s_j \in \{A, B\}$, or $\widetilde{m}_i(s_j) = \emptyset$ (i.e., $g_{ij}^* = 0$) for all $s_j \in \{A, B\}$.

We now define a voting strategy profile v for any transmission network g^* as follows: Order the experts according to their degrees d_j^* in g^* in decreasing order, indicate the experts with the highest degree in the transmission network by the index δ_1^* and the experts with the second-highest degree with the index δ_2^* , etc. Indicate the lowest degree of experts by index δ_M^* and the lowest possible degree of non-experts by index $\delta_N^* = 0$.³⁵ Order the non-experts according to their degrees d_i^* in decreasing order, indicate the experts with degree one in the transmission network by the index 1 and the non-experts with degree zero with the index 0. Then, a strategy profile on the voting stage is given by

$$s = \left\{ \begin{array}{l} v_{\delta_1}(A), v_{\delta_1}(B); v_{\delta_2}(A), v_{\delta_2}(B); \dots, v_{\delta_M}(A), v_{\delta_M}(B); \\ v_1(A), v_1(B), v_1(\emptyset); v_0(A), v_0(B), v_0(\emptyset) \end{array} \right\}.$$

C.1.1 Example 1

In Example 1, we have two possibilities. Either the transmission network is empty due to a babbling equilibrium. Then, the strategy profiles conforming to our selection criteria imply that a number $x \in \{1, 3, 5\}$ of experts vote their signal while all other players abstain. These strategy profiles are all equilibria. They obviously include a “let the experts decide equilibrium (LTED)”;³⁵ all other equilibria might be called “let some experts decide (LSED)” equilibria. The second possibility is that $r \in \{1, 2, 3, 4\}$ experts transmit their signal to the non-expert linked to them, while the remaining experts do not. (Note that we fully characterize g^* by r in this example.) Hence, there are two possible types of experts and two types of non-experts:

³⁵The lowest degree of non-experts is zero off equilibrium, even though it might be one on the equilibrium path.

those with degree $d_l^* = 1$ and those with $d_l^* = 0$. Hence, the strategy profiles on the voting stage are of the form

$$v = \{v_1(A), v_1(B); v_2(A), v_2(B); v_1(A), v_1(B), v_1(\emptyset); v_0(A), v_0(B), v_0(\emptyset)\}.$$

The strategy profiles on the voting stage that conform to our selection criteria Purity, Symmetry, Monotonicity, and Neutrality are as follows:

$$\begin{aligned} v_1 &= \{A, B; A, B; A, B, \emptyset; \emptyset\}, \\ v_2 &= \{A, B; A, B; \emptyset, \emptyset, \emptyset; \emptyset\}, \\ v_3 &= \{A, B; \emptyset, \emptyset; A, B, \emptyset; \emptyset\}, \\ v_4 &= \{A, B; \emptyset, \emptyset; \emptyset, \emptyset, \emptyset; \emptyset\}, \\ v_5 &= \{\emptyset, \emptyset; A, B; A, B, \emptyset; \emptyset\}, \\ v_6 &= \{\emptyset, \emptyset; A, B; \emptyset, \emptyset, \emptyset; \emptyset\}, \\ v_7 &= \{\emptyset, \emptyset; \emptyset, \emptyset; A, B, \emptyset; \emptyset\}, \text{ and} \\ v_8 &= \{\emptyset, \emptyset; \emptyset, \emptyset; \emptyset, \emptyset, \emptyset; \emptyset\}. \end{aligned}$$

Checking deviation incentives for all types of players and all strategy profiles on both the communication and the voting stage reveals the following result that we state without proof.³⁶

Proposition C.1. *Strategy profile v_1 and $r \in \{3, 4\}$ are (sincere) equilibria; v_2 and $r \in \{1, 2, 3, 4\}$ are (“let the experts decide”) equilibria; v_3 and $r \in \{1, 3\}$ are equilibria (with sincere voting and expert abstention); v_4 and $r \in \{1, 3\}$ are (“let some experts decide”) equilibria; v_5 and $r \in \{1, 2, 3, 4\}$ are (delegation) equilibria and outcome-equivalent to σ^* ; v_6 and $r \in \{2, 4\}$ are (“let some experts decide”) equilibria; v_7 and $r \in \{1, 3\}$ are (delegation) equilibria.*

The equilibria characterized in the above proposition are also depicted in Figure 10.

C.1.2 Example 2

Again, we have two possibilities. Either the transmission network is empty due to a babbling equilibrium and the same kind of equilibria exist as specified above for this case. The second possibility is that the center of the star (expert 1) transmits her signal to all non-experts. We now consider this second possibility and refer to the resulting transmission network as g_2^* . The strategy profiles on the voting stage that conform to our selection criteria Purity, Symmetry, Monotonicity, and Neutrality are as follows:

$$\begin{aligned} v_1 &= \{A, B; A, B; A, B, \emptyset\}, \\ v_2 &= \{A, B; A, B; \emptyset, \emptyset, \emptyset\}, \\ v_3 &= \{A, B; \emptyset, \emptyset; A, B, \emptyset\}, \\ v_4 &= \{A, B; \emptyset, \emptyset; \emptyset, \emptyset, \emptyset\}, \\ v_5 &= \{\emptyset, \emptyset; A, B; A, B, \emptyset\}, \\ v_6 &= \{\emptyset, \emptyset; A, B; \emptyset, \emptyset, \emptyset\}, \end{aligned}$$

³⁶The proof of this and all other propositions in this subsection can be obtained by the authors upon request.

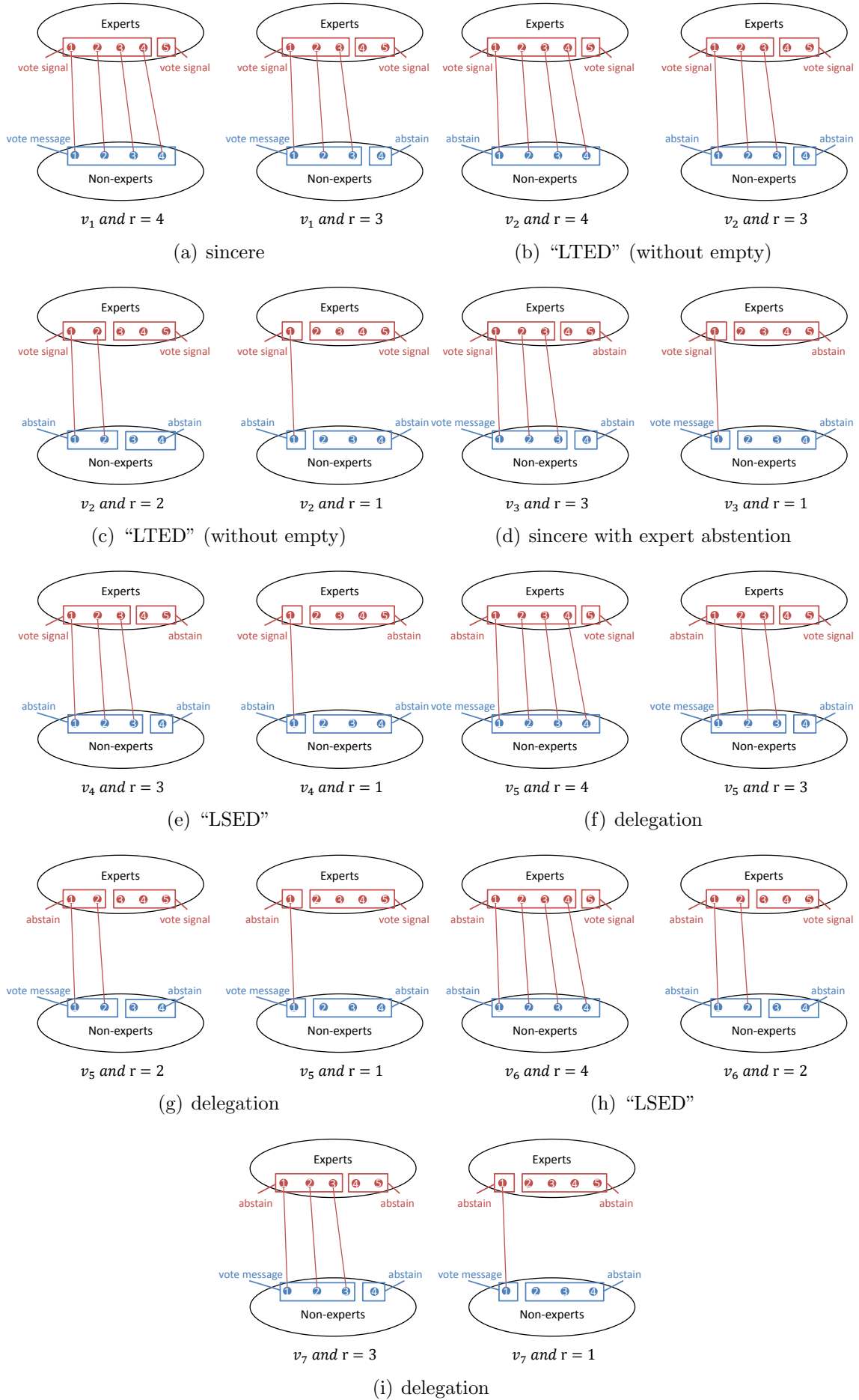


Figure 10: All equilibria of Proposition C.1.

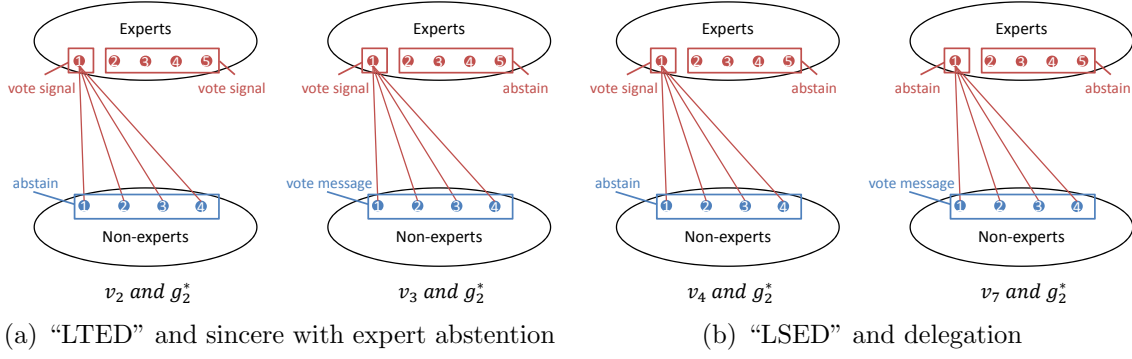


Figure 11: All equilibria of Proposition C.2.

$$v_7 = \{\emptyset, \emptyset; \emptyset, \emptyset; A, B, \emptyset\}, \text{ and}$$

$$v_8 = \{\emptyset, \emptyset; \emptyset, \emptyset; \emptyset, \emptyset, \emptyset\}.$$

Checking deviation incentives for all types of players and all strategy profiles on both the communication and the voting stage reveals the following result.

Proposition C.2. *Strategy profile v_2 and g_2^* are (“let the experts decide”) equilibria; v_3 and g_2^* are equilibria (with sincere voting and expert abstention); v_4 and g_2^* are (“let some experts decide”) equilibria; v_7 and g_2^* are (delegation) equilibria.*

The equilibria characterized in the above proposition are also depicted in Figure 11.

C.1.3 Example 3

In this example we have three possibilities which reduce to two if we ignore the empty transmission network that has been discussed above. These two possibilities are the following: (1) Either $g_{ij} = g_{ij}^*$ for all $i, j \in N \cup M$; then, the two experts with degree two in g are symmetric, the two non-experts listening to the same expert are symmetric, and the three experts with degree zero in g are symmetric. (2) Or degree $d_j = d_j^* = 2$ for exactly one expert j and $d_{j'} = 0$ for the other expert j' who has degree $d_{j'} = 1$ in g . Then, this other expert j' is symmetric to the experts with degree zero in g ; the two non-experts i with $g_{ij}^* = 1$ are symmetric, and the two non-experts with $g_{ij}^* = 0$ are symmetric.

Possibility (1). Let us first consider the case in which the transmission network equals the exogenous network; and let g_{31}^* denote this network. Then, the profiles on the voting stage that conform to our selection criteria Purity, Symmetry, Monotonicity, and Neutrality are as follows:

$$v_1 = \{A, B; A, B; A, B, \emptyset\},$$

$$v_2 = \{A, B; A, B; \emptyset, \emptyset, \emptyset\},$$

$$v_3 = \{A, B; \emptyset, \emptyset; A, B, \emptyset\},$$

$$v_4 = \{A, B; \emptyset, \emptyset; \emptyset, \emptyset, \emptyset\},$$

$$\begin{aligned}
v_5 &= \{\emptyset, \emptyset; A, B; A, B, \emptyset\}, \\
v_6 &= \{\emptyset, \emptyset; A, B; \emptyset, \emptyset, \emptyset\}, \\
v_7 &= \{\emptyset, \emptyset; \emptyset, \emptyset; A, B, \emptyset\}, \text{ and} \\
v_8 &= \{\emptyset, \emptyset; \emptyset, \emptyset; \emptyset, \emptyset, \emptyset\}.
\end{aligned}$$

Checking deviation incentives for all types of players and all strategy profiles on both the communication and the voting stage reveals the following result.

Proposition C.3. *Strategy profile v_1 and g_{31}^* are (sincere) equilibria; v_2 and g_{31}^* are (“let the experts decide”) equilibria; v_5 and g_{31}^* are (delegation) equilibria; v_6 and g_{31}^* are (“let some experts decide”) equilibria.*

The equilibria characterized in the above proposition are also depicted in Figure 12 below.

Possibility (2). Let us now consider the case in which the transmission network differs from the exogenous network in that only one expert transmits his signal, and let us refer to this transmission network as g_{32}^* . Then, the profiles on the voting stage that conform to our selection criteria Purity, Symmetry, Monotonicity, and Neutrality are as follows:

$$\begin{aligned}
v_1 &= \{A, B; A, B; A, B, \emptyset; \emptyset\}, \\
v_2 &= \{A, B; A, B; \emptyset, \emptyset, \emptyset; \emptyset\}, \\
v_3 &= \{A, B; \emptyset, \emptyset; A, B, \emptyset; \emptyset\}, \\
v_4 &= \{A, B; \emptyset, \emptyset; \emptyset, \emptyset, \emptyset; \emptyset\}, \\
v_5 &= \{\emptyset, \emptyset; A, B; A, B, \emptyset; \emptyset\}, \\
v_6 &= \{\emptyset, \emptyset; A, B; \emptyset, \emptyset, \emptyset; \emptyset\}, \\
v_7 &= \{\emptyset, \emptyset; \emptyset, \emptyset; A, B, \emptyset; \emptyset\}, \text{ and} \\
v_8 &= \{\emptyset, \emptyset; \emptyset, \emptyset; \emptyset, \emptyset, \emptyset; \emptyset\}.
\end{aligned}$$

Checking deviation incentives for all types of players and all strategy profiles on both the communication and the voting stage reveals the following result that we state without proof.

Proposition C.4. *Strategy profile v_2 and g_{32}^* are (“let the experts decide”) equilibria; v_3 and g_{32}^* are equilibria (sincere voting with some experts abstaining); v_4 and g_{32}^* are (“let some experts decide”) equilibria; v_7 and g_{32}^* are (delegation) equilibria.*

The equilibria characterized in the above proposition are also depicted in Figure 12.

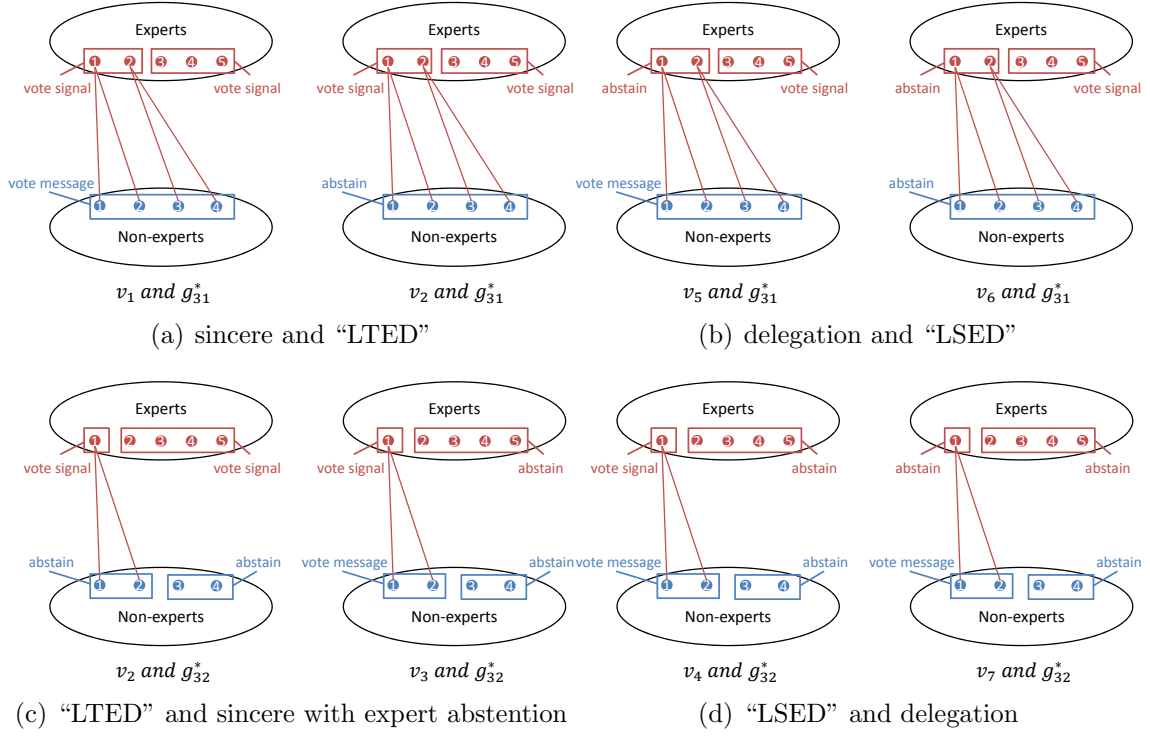


Figure 12: All equilibria of Propositions C.3 and C.4 .

C.2 A Necessary and Sufficient Condition

Proposition C.5. *Let m be odd and $\sum_j d_j =: l$ be even. The sincere strategy profile $\hat{\sigma}$ is an equilibrium if and only if the following conditions hold.*

1. *If $\exists i \in N$ with $d_i = 0$, then*

$\sum_{x=1,3,\dots,m} \left(p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2}} - (1-p)^{\frac{m+x}{2}} p^{\frac{m-x}{2}} \right) [\nu(x, 1) - \nu(-x, 1)] \geq 0$, where $\nu(x, 1)$ denotes the number of “sub-multisets” of multiset $\{d_1 + 1, \dots, d_m + 1\}$ which are of size $\frac{m+x}{2}$ and whose elements sum up to $\frac{m+l+1}{2}$.³⁷

2. $\forall d_j \in \{d_1, \dots, d_m\}$ such that $d_j > 0$ and for all $\bar{y} \in \{1, 2, d_j, d_j + 1, d_j + 2, 2d_j, 2d_j + 1, 2d_j + 2\}$ the following holds:

- (i) *if $\bar{y}$ even, then $\sum_{x=-m+2, -m+4, \dots, m} \left(p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2}} - (1-p)^{\frac{m+x}{2}} p^{\frac{m-x}{2}} \right) \cdot \sum_{y=1,3,\dots,\bar{y}-1} \nu(x, y|d_j) \geq 0$, and*
- (ii) *if $\bar{y}$ odd, then $\sum_{x=-m+2, -m+4, \dots, m} \left(p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2}} - (1-p)^{\frac{m+x}{2}} p^{\frac{m-x}{2}} \right) \cdot \left[\sum_{y=1,3,\dots,\bar{y}-2} (\nu(x, y|d_j) + \frac{1}{2}\nu(x, \bar{y}|d_j)) \right] \geq 0$,*

where $\nu(x, y|d_j)$ denotes the number of “sub-multisets” of multiset $\{d_1 + 1, \dots, d_m + 1\}$ which include element $d_j + 1$, are of size $\frac{m+x}{2}$, and whose elements sum up to $\frac{m+l+y}{2}$.

³⁷In a multiset the same numbers can occur several times. In full analogy to the notion of a subset, we call a multiset that is contained in another multiset a “sub-multiset.”

Proof. Part I shows necessity; part II shows sufficiency.

Part I. “ONLY IF”. Suppose $\hat{\sigma}$ is an equilibrium. We show that the two conditions of Prop. C.5 are satisfied.

1. Since $\hat{\sigma}$ is an equilibrium, no player can beneficially deviate. In particular, if there is a non-expert $i \in N$ without a link, i.e., the qualification of the first condition of Prop. C.5 holds, then for any deviation $\sigma'_i \in \Sigma'_i = \{A, B\}$, we have $EU(\hat{\sigma}_{-i}, \hat{\sigma}_i) \geq EU(\sigma_{-i}, \sigma'_i)$. W.l.o.g. suppose that $\sigma'_i = B$. Letting y denote the outcome under $\hat{\sigma}$ defined as the number of votes for A minus the number of votes for B , we observe that the deviation reduces the outcome y by one vote (because i votes for B instead of abstaining). The deviation σ'_i thus only affects the outcome if $y = +1$ and turns it into $y' = 0$ (i.e., if A wins by one vote under $\hat{\sigma}$, while there is a tie under $\sigma' := (\hat{\sigma}_{-i}, \sigma'_i)$). Restricting attention to these draws of nature, we must still have that the sincere strategy profile leads to higher expected utility since it is an equilibrium by assumption:

$$EU_{|y=1}(\hat{\sigma}_{-i}, \hat{\sigma}_i) \geq EU_{|y=1}(\hat{\sigma}_{-i}, \sigma'_i) = \frac{1}{2}. \quad (\text{C.1})$$

The right-hand side (RHS) is $\frac{1}{2}$ because this is the expected utility of a tie. Some more notation is helpful. Let x denote a distribution of signals defined as the number of A -signals minus the number of B -signals received by all experts. Let $P(x|A)$ denote the likelihood that the signals are x when the true state is A , and likewise for $P(x|B)$. Let $\hat{P}(x, y)$ designate the probability that signals x lead to outcome y under $\hat{\sigma}$. Then we can rewrite inequality C.1 as

$$\frac{\frac{1}{2} \sum_{x=-m, -m+2, \dots, m} P(x|A) \hat{P}(x, 1)}{\frac{1}{2} \sum_{x=-m, -m+2, \dots, m} (P(x|A) \hat{P}(x, 1) + P(x|B) \hat{P}(x, 1))} \geq \frac{1}{2}, \quad (\text{C.2})$$

since the expected utility under $\hat{\sigma}$ when restricting attention to the draws of nature that lead to a win of A by one vote equals the probability that A is true under these conditions.

This simplifies to

$$\sum_{x=-m, -m+2, \dots, m} P(x|A) \hat{P}(x, 1) \geq \sum_{x=-m, -m+2, \dots, m} P(x|B) \hat{P}(x, 1) \quad (\text{C.3})$$

and further to

$$\sum_{x=-m, -m+2, \dots, m} (P(x|A) - P(x|B)) \hat{P}(x, 1) \geq 0. \quad (\text{C.4})$$

Now, we split the sum into positive and negative values of x and finally rejoin

them by using $P(x|A) = P(-x|B)$:

$$\begin{aligned}
& \sum_{x=-m, -m+2, \dots, m} (P(x|A) - P(x|B)) \hat{P}(x, 1) \geq 0 \\
& \Leftrightarrow \sum_{x=1, 3, \dots, m} (P(x|A) - P(x|B)) \hat{P}(x, 1) \\
& + \sum_{x=-m, -m+2, \dots, -1} (P(x|A) - P(x|B)) \hat{P}(x, 1) \geq 0 \\
& \Leftrightarrow \sum_{x=1, 3, \dots, m} (P(x|A) - P(x|B)) \hat{P}(x, 1) \\
& + \sum_{x=1, 3, \dots, m} (P(-x|A) - P(-x|B)) \hat{P}(-x, 1) \geq 0 \\
& \Leftrightarrow \sum_{x=1, 3, \dots, m} (P(x|A) - P(x|B)) \hat{P}(x, 1) \\
& + \sum_{x=1, 3, \dots, m} (P(x|B) - P(x|A)) \hat{P}(-x, 1) \geq 0 \\
& \Leftrightarrow \sum_{x=1, 3, \dots, m} (P(x|A) - P(x|B)) [\hat{P}(x, 1) - \hat{P}(-x, 1)] \geq 0 \\
& \Leftrightarrow \sum_{x=1, 3, \dots, m} (P(x|A) - P(-x|A)) [\hat{P}(x, 1) - \hat{P}(-x, 1)] \geq 0.
\end{aligned}$$

Independent of the strategy profile, $P(x|A) = \binom{m}{\frac{m+x}{2}} p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2}}$. For a draw of signals with difference x (in numbers of A -signals and B -signals), the outcome $y = +1$ is reached under $\hat{\sigma}$ if there are exactly $\frac{m+l+1}{2}$ votes for A . All of the A -votes under $\hat{\sigma}$ can be partitioned such that each element of the partition is referred to an expert j with signal A . Such an expert accounts for $d_j + 1$ votes because there is her vote and the votes of her audience. Hence, the probability that draw of nature x leads to outcome $y = +1$ is determined by the frequency with which $\frac{m+x}{2}$ experts who have received signal A account for exactly $\frac{m+l+1}{2}$ votes. This frequency is given by the number of “sub-multisets” of multiset $\{d_1 + 1, \dots, d_m + 1\}$ which have size $\frac{m+x}{2}$ and whose elements sum up to $\frac{m+l+1}{2}$.

Considering all possible allocations of $\frac{m+x}{2}$ A -signals among m experts, there are $\binom{m}{\frac{m+x}{2}}$ possibilities (which is the number of all “sub-multisets” of multiset $\{d_1 + 1, \dots, d_m + 1\}$ of size $\frac{m+x}{2}$). Therefore, the probability that signals x lead to outcome $y = +1$ is

$$\hat{P}(x, +1) = \frac{\nu(x, 1)}{\binom{m}{\frac{m+x}{2}}},$$

where $\nu(x, 1)$ denotes the number of “sub-multisets” of multiset $\{d_1 + 1, \dots, d_m + 1\}$ of size $\frac{m+x}{2}$ and sum $\frac{m+l+1}{2}$.

Plugging the equations for $P(x|A)$ and $\hat{P}(x, 1)$ into the inequality derived

above yields:

$$\sum_{x=1,3,\dots,m} \left(\left(\frac{m}{\frac{m+x}{2}} \right) p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2}} - \left(\frac{m}{\frac{m-x}{2}} \right) (1-p)^{\frac{m+x}{2}} p^{\frac{m-x}{2}} \right) \cdot \left[\frac{\nu(x, 1)}{\left(\frac{m}{\frac{m+x}{2}} \right)} - \frac{\nu(-x, 1)}{\left(\frac{m}{\frac{m-x}{2}} \right)} \right] \geq 0. \quad (\text{C.5})$$

Since $\left(\frac{m}{\frac{m-x}{2}} \right) = \left(\frac{m}{\frac{m+x}{2}} \right)$, these factors cancel out such that we get

$$\sum_{x=1,3,\dots,m} \left(p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2}} - (1-p)^{\frac{m+x}{2}} p^{\frac{m-x}{2}} \right) [\nu(x, 1) - \nu(-x, 1)] \geq 0. \quad (\text{C.6})$$

This shows that the first condition of Prop. C.5 is indeed implied by the assumption that $\hat{\sigma}$ is an equilibrium.

2. Let us turn to the second condition of Prop. C.5 by considering some expert $j \in M$ with $d_j > 0$. W.l.o.g. let her signal be A . Under the sincere strategy profile j will vote and communicate her signal, i.e., A . Abstention reduces the outcome y by one vote, voting the opposite reduces the outcome y by two votes. Sending no message reduces the outcome by d_j votes. Sending the opposite message reduces the outcome by $2d_j$ votes. Therefore, there are feasible deviations for j that reduce the outcome by a number of votes $\bar{y}$ which is in the following set $\{1, 2, d_j, d_j + 1, d_j + 2, 2d_j, 2d_j + 1, 2d_j + 2\}$.

By the assumption that $\hat{\sigma}$ is an equilibrium, there is no beneficial deviation for j . That is, for any deviation $\sigma'_j \in \Sigma'_j$, we have $EU^{s_j=A^*}(\hat{\sigma}_{-j}, \hat{\sigma}_j) \geq EU^{s_j=A^*}(\hat{\sigma}_{-j}, \sigma'_j)$. Considering some deviation σ'_j and the corresponding reduction of the outcome by $\bar{y}$, the implemented alternatives only differ for draws of nature such that $y > 0$ and $y' \leq 0$, i.e for outcomes y such that $0 < y \leq \bar{y}$ (because only then the reduction of support for the received signal has any effect). Therefore, the inequality of expected utility must also hold when focusing on these cases, i.e.

$$EU_{|0 < y \leq \bar{y}}^{s_j=A^*}(\hat{\sigma}_{-j}, \hat{\sigma}_j) \geq EU_{|0 < y \leq \bar{y}}^{s_j=A^*}(\hat{\sigma}_{-j}, \sigma'_j). \quad (\text{C.7})$$

(i) Suppose first that $\bar{y}$ is even. Then the deviation σ'_j turns all outcomes in which A wins and $0 < y \leq \bar{y} - 1$ into a win of alternative B (outcomes $y = \bar{y}$ are not possible because y is odd). Therefore, the expected utility of strategy profile $\hat{\sigma}$ (respectively, $\sigma' := (\hat{\sigma}_{-j}, \sigma'_j)$), focusing on these cases, is the probability that A (respectively, B) is true in these cases. Let $P_{s_j=A^*}(x|\omega = A) =: P_A(x|A)$ denote the probability that the signal distribution is x and that expert j has received signal A when the true state is A , and similarly for $P_{s_j=A^*}(x|\omega = B) =: P_A(x|B)$. Moreover, let $\hat{P}_{s_j=A^*}(x, y) =: \hat{P}_A(x, y)$ be the probability that the signals x lead to outcome y under $\hat{\sigma}$, given that expert j has received signal A . Note that $\hat{P}_A(x, y)$ is not defined for $x = -m$ because if

all experts have received signal B it is not possible that expert j has received signal A . Then we can rewrite inequality C.7 as

$$\sum_{x=-m+2, -m+4, \dots, m} P_A(x|A) \sum_{y=1, 3, \dots, \bar{y}-1} \hat{P}_A(x, y) \geq \sum_{x=-m+2, -m+4, \dots, m} P_A(x|B) \sum_{y=1, 3, \dots, \bar{y}-1} \hat{P}_A(x, y). \quad (\text{C.8})$$

inequality C.8 incorporates that the likelihood of A being true is greater or equal than the likelihood of B being true given that the deviation is effective and that expert j has received signal A .³⁸ This inequality simplifies to

$$\sum_{x=-m+2, -m+4, \dots, m} (P_A(x|A) - P_A(x|B)) \cdot \sum_{y=1, 3, \dots, \bar{y}-1} \hat{P}_A(x, y) \geq 0. \quad (\text{C.9})$$

Independent of the strategy profile, $P_A(x|A) = \binom{m}{\frac{m+x}{2}} p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2}} \cdot \frac{m+x}{m}$ and $P_A(x|B) = \binom{m}{\frac{m-x}{2}} p^{\frac{m-x}{2}} (1-p)^{\frac{m+x}{2}} \cdot \frac{m+x}{m}$. The factor before the multiplication sign is the probability that there are exactly $\frac{m+x}{2}$ A -signals. Given such a distribution, the factor after the multiplication sign is the probability that expert j has received signal A .

For a distribution of signals x , the outcome y is reached under $\hat{\sigma}$ if there are exactly $\frac{m+l+y}{2}$ votes for A . All of the A -votes under $\hat{\sigma}$ can be partitioned such that each element is referred to an expert k with signal A . Such an expert accounts for $d_k + 1$ votes (because there is her vote and the votes of her audience). By assumption, expert j has received signal A and thus there are at least $d_j + 1$ votes for A under $\hat{\sigma}$. The probability that draw of nature x leads to outcome y is determined by the frequency that the $\frac{m+x}{2}$ experts who have received signal A account for exactly $\frac{m+l+y}{2}$ votes. Hence, this frequency is given by the number of “sub-multisets” of multiset $\{d_1 + 1, \dots, d_m + 1\}$ which include element $d_j + 1$, are of size $\frac{m+x}{2}$, and whose elements sum up to $\frac{m+l+y}{2}$. Considering all possible allocations of $\frac{m+x}{2}$ A -signals among m experts such that j also receives signal A , there are $\binom{m-1}{\frac{m+x}{2}-1}$ possibilities (which is the number of all “sub-multisets” of multiset $\{d_1 + 1, \dots, d_m + 1\}$ which include element $d_j + 1$ and are of size $\frac{m+x}{2}$). Therefore, the probability that signals x lead to outcome y , given that expert j has received signal A , is

$$\hat{P}_A(x, y) = \frac{\nu(x, y|d_j)}{\binom{m-1}{\frac{m+x}{2}-1}},$$

where $\nu(x, y|d_j)$ denotes the number of “sub-multisets” of multiset $\{d_1 + 1, \dots, d_m + 1\}$ which include element $d_j + 1$, are of size $\frac{m+x}{2}$, and whose elements sum up to $\frac{m+l+y}{2}$.

³⁸To get the absolute probabilities of A (respectively B) being true, we can divide the LHS (respectively the RHS) of inequality C.8 by the sum of the LHS and the RHS.

Hence, we can rewrite inequality C.9 as follows

$$\begin{aligned}
& \sum_{x=-m+2, -m+4, \dots, m} (P_A(x|A) - P_A(x|B)) \sum_{y=1, 3, \dots, \bar{y}-1} \hat{P}_A(x, y) \geq 0 \\
& \Leftrightarrow \sum_{x=-m+2, -m+4, \dots, m} \left(\left(\frac{m}{\frac{m+x}{2}} \right) p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2}} \frac{\frac{m+x}{2}}{m} \right. \\
& \quad \left. - \left(\frac{m}{\frac{m-x}{2}} \right) (1-p)^{\frac{m+x}{2}} p^{\frac{m-x}{2}} \frac{\frac{m-x}{2}}{m} \right) \sum_{y=1, 3, \dots, \bar{y}-1} \frac{\nu(x, y|d_j)}{\binom{\frac{m-1}{2}}{\frac{m+x}{2}-1}} \geq 0 \\
& \Leftrightarrow \sum_{x=-m+2, -m+4, \dots, m} \left(\frac{m}{\frac{m+x}{2}} \right) \frac{\frac{m+x}{2}}{m} \left(p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2}} - (1-p)^{\frac{m+x}{2}} p^{\frac{m-x}{2}} \right) \\
& \quad \cdot \sum_{y=1, 3, \dots, \bar{y}-1} \frac{\nu(x, y|d_j)}{\binom{\frac{m-1}{2}}{\frac{m+x}{2}-1}} \geq 0.
\end{aligned}$$

We have used that $\binom{m}{\frac{m+x}{2}} = \binom{m}{\frac{m-x}{2}}$. Finally, we observe that the factors $\binom{m}{\frac{m+x}{2}}$, $\frac{\frac{m+x}{2}}{m}$, and $\frac{1}{\binom{\frac{m-1}{2}}{\frac{m+x}{2}-1}}$ simplify to one because $\frac{\binom{m}{\frac{m+x}{2}}}{\binom{\frac{m-1}{2}}{\frac{m+x}{2}-1}} = \frac{m}{\frac{m+x}{2}}$ such that we get

$$\sum_{x=-m+2, -m+4, \dots, m} \left(p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2}} - (1-p)^{\frac{m+x}{2}} p^{\frac{m-x}{2}} \right) \sum_{y=1, 3, \dots, \bar{y}-1} \nu(x, y|d_j) \geq 0 \quad (\text{C.10})$$

We have shown that inequality C.10, which coincides with condition 2(i) of Prop. C.5, holds for any $\bar{y} \in \{1, 2, d_j, d_j + 1, d_j + 2, 2d_j, 2d_j + 1, 2d_j + 2\}$ even.

(ii) Suppose now that $\bar{y}$ is odd. (Still, we keep the assumption that some expert $j \in M$ with $d_j > 0$ has received signal A and considers a deviation σ'_j that reduces the outcome by $\bar{y}$). Then the deviation σ'_j turns all outcomes in which A wins and $0 < y \leq \bar{y}$ into a win of alternative B for $y = 1, 3, \dots, \bar{y} - 2$ and into a tie for $y = \bar{y}$. Therefore,

$$\begin{aligned}
& EU_{|0 < y \leq \bar{y}}^{s_j=A^*}(\hat{\sigma}_{-j}, \sigma'_j) = \\
& \frac{\sum_{x=-m+2, -m+4, \dots, m} (P_A(x|B) (\sum_{y=1, 3, \dots, \bar{y}-2} P_A(x, y) + \frac{1}{2} \hat{P}_A(x, \bar{y})) + \frac{1}{2} P_A(x|A) \hat{P}_A(x, \bar{y}))}{\sum_{x=-m+2, -m+4, \dots, m} (P_A(x|A) + P_A(x|B)) \sum_{y=1, 3, \dots, \bar{y}} \hat{P}_A(x, y)}.
\end{aligned}$$

The denominator is the probability that an outcome under $\hat{\sigma}$ is reached such that the deviation has some effect. The numerator consists of the probability that B is true for the cases where the deviation leads to a win of alternative B and of half the probabilities that A or B are true when the deviation leads to a tie.

The expected utility of the sincere strategy profile amounts to

$$EU_{|0 < y \leq \bar{y}}^{s_j=A^*}(\hat{\sigma}_{-j}, \hat{\sigma}_j) = \frac{\sum_{x=-m+2, -m+4, \dots, m} P_A(x|A) (\sum_{y=1, 3, \dots, \bar{y}-2} \hat{P}_A(x, y) + \hat{P}_A(x, \bar{y}))}{\sum_{x=-m+2, -m+4, \dots, m} (P_A(x|A) + P_A(x|B)) \sum_{y=1, 3, \dots, \bar{y}} \hat{P}_A(x, y)}.$$

The numerator is the probability that A is true under the cases where the deviation has some effect. Since the denominator is the same as above, we can rewrite inequality C.7 as

$$\begin{aligned}
& \sum_{x=-m+2, -m+4, \dots, m} \left(P_A(x|A) \left(\sum_{y=1, 3, \dots, \bar{y}-2} \hat{P}_A(x, y) + \hat{P}_A(x, \bar{y}) \right) - P_A(x|B) \right. \\
& \quad \cdot \left. \left(\sum_{y=1, 3, \dots, \bar{y}-2} \hat{P}_A(x, y) + \frac{1}{2} \hat{P}_A(x, \bar{y}) \right) - \frac{1}{2} P_A(x|A) \hat{P}_A(x, \bar{y}) \right) \geq 0 \text{ and further}
\end{aligned}$$

simplify it to

$$\sum_{x=-m+2, -m+4, \dots, m} (P_A(x|A) - P_A(x|B)) \cdot \left(\sum_{y=1, 3, \dots, \bar{y}-2} \hat{P}(x, y|d_j) + \frac{1}{2} \hat{P}_A(x, \bar{y}) \right) \geq 0. \quad (\text{C.11})$$

Now, we plug in $P_A(x|A) = \binom{m}{\frac{m+x}{2}} p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2} \frac{m+x}{m}}$ and $P_A(x|B) = \binom{m}{\frac{m-x}{2}} p^{\frac{m-x}{2}} (1-p)^{\frac{m+x}{2} \frac{m-x}{m}}$; as well as $\hat{P}_A(x, y) = \frac{\nu(x, y|d_j)}{\binom{m-1}{\frac{m+x}{2}-1}}$. This yields:

$$\sum_{x=-m+2, -m+4, \dots, m} \left(\binom{m}{\frac{m+x}{2}} \frac{m+x}{m} \left(p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2}} - (1-p)^{\frac{m+x}{2}} p^{\frac{m-x}{2}} \right) \right) \cdot \left(\sum_{y=1, 3, \dots, \bar{y}-2} \frac{\nu(x, y|d_j)}{\binom{m-1}{\frac{m+x}{2}-1}} + \frac{1}{2} \frac{\nu(x, \bar{y}|d_j)}{\binom{m-1}{\frac{m+x}{2}-1}} \right) \geq 0. \quad (\text{C.12})$$

Again, the factors $\binom{m}{\frac{m+x}{2}}$, $\frac{m+x}{m}$, and $\frac{1}{\binom{m-1}{\frac{m+x}{2}-1}}$ cancel out since their product is 1. Hence, inequality C.12 becomes

$$\sum_{x=-m+2, -m+4, \dots, m} \left(p^{\frac{m+x}{2}} (1-p)^{\frac{m-x}{2}} - (1-p)^{\frac{m+x}{2}} p^{\frac{m-x}{2}} \right) \cdot \left(\sum_{y=1, 3, \dots, \bar{y}-2} \nu(x, y|d_j) + \frac{1}{2} \nu(x, \bar{y}|d_j) \right) \geq 0. \quad (\text{C.13})$$

Inequality C.13 holds for any $\bar{y} \in \{1, 2, d_j, d_j + 1, d_j + 2, 2d_j, 2d_j + 1, 2d_j + 2\}$ odd and coincides with condition 2(ii) of Prop. C.5.

We have derived the implications for an arbitrary expert with degree $d_j > 0$ and for some arbitrary $\bar{y} \in \{1, 2, d_j, d_j + 1, d_j + 2, 2d_j, 2d_j + 1, 2d_j + 2\}$. The derived conditions 2(i) and 2(ii) must hence hold for any $d_j \in \{d_1, \dots, d_m\}$ such that $d_j > 0$. For the case of the empty network, in which no single expert has an audience, the strategy profile $\hat{\sigma}$ is not interesting to study because communication is impossible, but formally still Prop. C.5 applies. In this special case condition 2 is trivially satisfied. Thus, we have shown that if $\hat{\sigma}$ is an equilibrium, then the second condition of Prop. C.5 is also satisfied.

Part II. “IF”. Suppose that the two conditions of Prop. C.5 are satisfied. We show that $\hat{\sigma}$ is an equilibrium by deriving the implications of these two conditions for every kind of player.

- Non-experts without a link: Consider any non-expert $i \in N$ with $d_i = 0$. The set of strategies is $\{A, B, \phi\}$ and $\hat{\sigma}_i = \phi$. Suppose condition 1 of Prop. C.5

holds, which is inequality C.6. In part I of the proof we used a sequence of transformations to rewrite inequality C.1 as inequality C.6. Since these were all equivalence transformations, the assumption that inequality C.6 holds implies that inequality C.1 holds. Thus, condition 1 of Prop. C.5 implies that for a non-expert without a link deviating from $\hat{\sigma}$ does not increase expected utility, given that the outcome is $y = +1$, i.e., given that the deviation has any effect on the outcome.

- Experts with an audience: Consider any expert $j \in M$ with $d_j > 0$. This expert has $(3 \times 3)^2 = 81$ strategies because she chooses one of three messages and one of three voting actions after receiving one of two signals. To evaluate different strategies we can assume w.l.o.g. that the expert has received signal A because neither the utility function nor the strategy profile depends on the label of the alternatives. This reduces the number of strategies to nine. Consider any deviation σ'_j . This deviation reduces the voting outcome y that is attained under $\hat{\sigma}$ by a number $\bar{y} \in \{1, 2, d_j, d_j + 1, d_j + 2, 2d_j, 2d_j + 1, 2d_j + 2\}$. For each of these numbers conditions 2(i) and 2(ii) of Prop. C.5 are equivalent to inequality C.7 since the conditions 2(i) and 2(ii) were derived by equivalence transformations of inequality C.7. Thus, for any deviation of an expert with an audience, the expected utility is weakly smaller than under $\hat{\sigma}$, when restricting attention to the cases where the deviation has some effect on the outcome and hence in general as well.
- Experts without an audience: Consider any expert $j \in M$ with $d_j = 0$. W.l.o.g. assume that j has received signal A . Under $\hat{\sigma}$ expert j would vote A . Alternatively, she can vote B respectively abstain, which reduces the outcome y by two respectively by one vote. (These deviations have already been considered for experts with an audience when letting $\bar{y} = 2$, respectively, $\bar{y} = 1$.) These deviations are not increasing expected utility since condition 2(i) of Prop. C.5 holds in particular for $\bar{y} = 2$ and condition 2(ii) of Prop. C.5 holds in particular for $\bar{y} = 1$ such that inequality C.7 is satisfied.
- Non-experts with a link: Consider any non-expert $i \in N$ with $d_i = 1$. W.l.o.g. assume that i has received message A . Under $\hat{\sigma}$ non-expert i votes A . Alternatively, he can vote B respectively abstain, which reduces the outcome y by two respectively by one vote. (The effect of these two deviations is as if an expert with signal A would vote for B respectively abstain.) Again, since condition 2(i) of Prop. C.5 holds in particular for $\bar{y} = 2$ and condition 2(ii) of Prop. C.5 holds in particular for $\bar{y} = 1$, inequality C.7 is satisfied such that these deviations do not increase expected utility.

We have shown in part II of the proof that the conditions 1 and 2 provided in Prop. C.5 imply that no player can beneficially deviate from $\hat{\sigma}$. $\square$

C.3 Partisans

C.3.1 Model with Partisans

We have so far assumed that all agents have the same preferences, namely they want the policy to match the state of the world. Now, we introduce agents who try to induce a specific policy regardless of the state of the world, e.g., due to the expectation of personal perquisites. We call them A -partisans or B -partisans according to their preferred policy. Throughout we assume that the number of A -partisans equals the number of B -partisans. We introduce partisans as members of the set M who can potentially communicate with non-experts in N . Non-experts cannot directly observe whether “their” sender is an expert or a partisan, but the number of experts m_E and the number of partisans $m_A = m_B$ are known.

Formally, we assume that the network g is given and that nature draws an allocation of the given experts and partisans to the nodes in M . Assuming that each allocation has the same probability, the probability that a given sender is an expert is simply $\frac{m_E}{m}$. We consider the position of each expert or partisan as her private information. Since partisans have no incentive to utilize signals about the true state of the world, we assume that they do not receive a signal.

We extend the definition of the two focal strategy profiles σ^* (“let the experts decide”) and $\hat{\sigma}$ (sincere) to the model with partisans by assuming that the latter communicate and vote their preferred alternative.³⁹ For each partisan j voting and communicating the preferred alternative is a best response to σ_{-j}^* , respectively to $\hat{\sigma}_{-j}$. For the “let the experts decide” strategy profile σ^* we assume in addition that all non-experts abstain independent of their received message such that they follow neither an expert’s nor a partisan’s message.

The notion of informational efficiency of Definition 1 still applies to this extension of the model. Note, however, that an informationally efficient strategy profile only maximizes the expected utility of all experts and non-experts, but generally not of any partisan.

The extension of the baseline model that incorporates partisans does not alter the results we have established so far. In particular, given that the number of A -partisans equals the number of B -partisans, Propositions 1, 2, and 3 carry over. This is formally shown as Propositions C.6, C.7, and C.8 in the next subsection.

C.3.2 Propositions with Partisans

Proposition C.6. *In the extended model with an equal number of partisans ($m_A = m_B$), there exist efficient equilibria for any network structure. For instance, the “let the experts decide” strategy profile σ^* is efficient and an equilibrium for any network structure.*

Proof. Since the votes of the partisans balance each other out, the “let the experts decide” strategy profile σ^* always implements the majority signal and is hence

³⁹By allocating experts to positions in M , the strategy space of an expert increases since they can potentially condition their strategy on the position. In the focal strategy profiles σ^* and $\hat{\sigma}$ the experts’ strategies do not rely on their position.

efficient. Therefore, it maximizes the expected utility for any expert and any non-expert.⁴⁰ Thus, we only have to check potential deviations of partisans. Deviations in the communication strategy are ineffective because all members of the audience abstain unconditionally under σ^* . Changing the voting action cannot increase expected utility because an A -partisan cannot increase the likelihood that A is chosen when deviating from voting for A ; and analogously for B -partisans. $\square$

Proposition C.7. *Consider the extended model with an equal number of partisans ($m_A = m_B$). Let $m = |M| \geq 5$, let m be odd, and let the number of links $l := \sum_{j=1}^m d_j$ be even. The sincere strategy profile $\hat{\sigma}$ is an equilibrium if (a) the network is strongly balanced, and only if either (b) the network is weakly balanced or there is an agent who is never pivotal. The sincere strategy profile $\hat{\sigma}$ is efficient if and only if (a) the network is strongly balanced.*

Proof. First, we observe that Lemma B.1 carries over to the model extension with partisans. In particular, representativeness (of g under $\hat{\sigma}$) is unaffected and it is equivalent to both condition (a), i.e., strong balancedness, and to informational efficiency (under $\hat{\sigma}$), given that $m_A = m_B$.

Now, suppose strong balancedness is satisfied. Then $\hat{\sigma}$ is efficient and, hence, experts and non-experts cannot improve by deviating. When an A -partisan effectively deviates from $\hat{\sigma}$ either she or her audience stops voting for A . This does not increase the likelihood that A is implemented. This holds analogously for B -partisans. Thus, there is no profitable deviation for any player.

It remains to show that weak balancedness is a necessary condition for $\hat{\sigma}$ to be an equilibrium; or there must be an agent who is never pivotal under $\hat{\sigma}$. Suppose that all agents can be pivotal under $\hat{\sigma}$. Let i be a non-expert listening to a sender with maximal degree d_1 and let w.l.o.g. A be the message received. Following the arguments of the proof of Prop. 2, we get the following: If weak balancedness (i.e., inequality B.8) is violated, then pivotality of non-expert i implies that a majority of the members of M (experts and partisans) have voted message B . Since $m_A = m_B$, B is then the majority signal and thus, the probability that A is true is below 0.5. Hence, non-expert i can improve by not voting the message. $\square$

Proposition C.8. *In the extended model with an equal number of partisans ($m_A = m_B$), there are networks in which the sincere strategy profile $\hat{\sigma}$ is both an equilibrium and exhibits informational inefficiency.*

Proof. We show the proposition by an example. Let $m = 7$, $m_A = m_B = 2$, and $n = 4$. Let the network structure be as in the weakly balanced network of the experimental treatments in Study II (i.e., the second network in the lower panel of Figure 3) such that the degree distribution of the experts and partisans is $(d_1, d_2, d_3, d_4, d_5, d_6, d_7) = (1, 1, 1, 1, 0, 0, 0)$. We first show that $\hat{\sigma}$ exhibits informational inefficiency and then that $\hat{\sigma}$ is an equilibrium.

⁴⁰With the presence of partisans efficient strategy profiles are not automatically equilibria anymore, but efficient strategy profiles with partisans who cannot improve are.

Inefficiency. To see that $\hat{\sigma}$ is inefficient, consider the relation between the signal distribution and the voting outcome. Suppose that two experts have received signal A and one expert has received signal B . Assume that the four non-experts happen to be linked to the two B -partisans, to the expert who received the signal B , and to one of the experts who received signal A . In this case, $\hat{\sigma}$ implies that B wins by one vote. Since this is an instance in which the majority signal is not chosen by the group, $\hat{\sigma}$ is not efficient in the current network.

Equilibrium. We show that none of the agents has an incentive to deviate from $\hat{\sigma}$. Consider first any non-expert $i \in N$. He is pivotal if without his vote the outcome of the election is a tie (5:5). This occurs either if there are two messages of each kind and i has received the majority signal as the message; or if there are three messages of the minority signal and one message of the majority signal and i has received the minority signal as the message. Non-expert i 's belief that his message, say A , is true, conditional on his pivotality, amounts to

$$p_i(A|A, \text{piv}) = \frac{3p^2(1-p)^{\frac{4}{7}} * \frac{9}{20} + 3p(1-p)^{\frac{2}{7}} * \frac{4}{20}}{3p^2(1-p)^{\frac{4}{7}} * \frac{9}{20} + 3p(1-p)^{\frac{2}{7}} * \frac{4}{20} + 3p(1-p)^{\frac{2}{7}} * \frac{9}{20} + 3p^2(1-p)^{\frac{3}{7}} * \frac{4}{20}}$$

and simplifies to

$$p_i(A|A, \text{piv}) = \frac{p^2(1-p)3 + p(1-p)^2}{[p^2(1-p) + p(1-p)^2](3+1)} > \frac{1}{2}.$$

Hence, non-expert i 's expected utility from following the message as prescribed by $\hat{\sigma}$ is larger than his utility from abstention or voting the opposite.

Now, consider an expert j with $d_j = 0$. Assume w.l.o.g. that j has received signal A . By deviating from $\hat{\sigma}_j$ this expert only changes the outcome if A would win by one vote (it is not possible that A wins by two votes). The draws of nature that lead to this outcome are all such that A is the majority signal. If A were the minority signal and expert j with $d_j = 0$ had received A , alternative B would get at least six votes (because there are two B -partisans and two experts with signal B and at least two of them have a non-expert who listens to them) and always win under $\hat{\sigma}$. Thus, j can only affect the outcome if A is the majority signal. Since the probability that A is correct is then above 0.5, a deviation from $\hat{\sigma}_j$ cannot increase expert j 's expected utility.

Now, consider an expert j with $d_j = 1$. A deviation only affects the outcome if the signal that j has received wins under $\hat{\sigma}$, but not when j deviates. W.l.o.g. assume that expert j has received signal A . Since j can reduce the number of votes for A by at most two and increase the number of votes for B by at most two (when he communicates and votes the opposite), the outcomes $\#A : \#B$ that expert j can overturn are 7:4 and 6:5. We proceed by showing for each of these outcomes that the probability that A is correct is above 0.5 such that there is no incentive to deviate from $\hat{\sigma}$, which implements A . The outcome 7:4 with j receiving A is reached under $\hat{\sigma}$ only if signals were 3:0 or 2:1 in favor of A . Since in these two cases the probability that A is true is above 0.5, overruling outcome 7:4 decreases expected utility. The outcome 6:5 can be based on two situations (as in the discussion of

non-experts above). First, it is possible that A is the majority signal and there were two messages A and two messages B . Second, it is possible that A is the minority signal and two A -partisans plus one expert (the one holding the minority signal) have sent message A . Using the probabilities of these two events, we observe that A is more likely to be true than B , given that j has received signal A and the outcome is 5:4, if and only if the following inequality holds:

$$3p^2(1-p)\frac{2}{3} * \frac{9}{20} + 3p(1-p)^2\frac{1}{3} * \frac{4}{20} \geq 3p(1-p)^2\frac{2}{3} * \frac{9}{20} + 3p^2(1-p)\frac{1}{3} * \frac{4}{20}.$$

The equation compares the probability that A is true when signals are 2:1 and 1:2 on the left-hand side with the probability that B is true when signals are 2:1 and 1:2 on the right-hand side, given that j has received signal A and the outcome is 5:4. The inequality simplifies to

$$(3p^2(1-p) - 3p(1-p)^2) \left[\frac{2}{3} * \frac{9}{20} - \frac{1}{3} * \frac{4}{20} \right] \geq 0,$$

which is true (since $p > \frac{1}{2}$). Hence, any outcome that an expert with an audience can overturn in this example is more likely to match the true state than the alternative.

Finally, partisans cannot improve by a deviation because, given the others' strategies under $\hat{\sigma}$, they can only reduce the likelihood of their preferred outcome by a deviation. Hence, $\hat{\sigma}$ is an equilibrium despite its informational inefficiency. $\square$

D Instructions

The original instructions are written in German and can be requested from the authors. On the next pages we provide an English version which is a sentence-by-sentence translation of the original instructions, first for Study I, then for Study II. The instructions of each study are followed by the questions of comprehension.

Welcome to today's experiment!

Please note that **no communication** is allowed from now on and during the whole experiment. If you have a question please raise your hand from the cabin, one of the experimenters will then come to you. The use of cell phones, smart phones, tablets, or similar devices is prohibited during the entire experiment. Please note that a violation of this rule leads to exclusion from the experiment and from any payments.

All decisions are taken anonymously, i.e. none of the other participants comes to know the identity of the others. The payoff is also conducted anonymously at the end of the experiment.

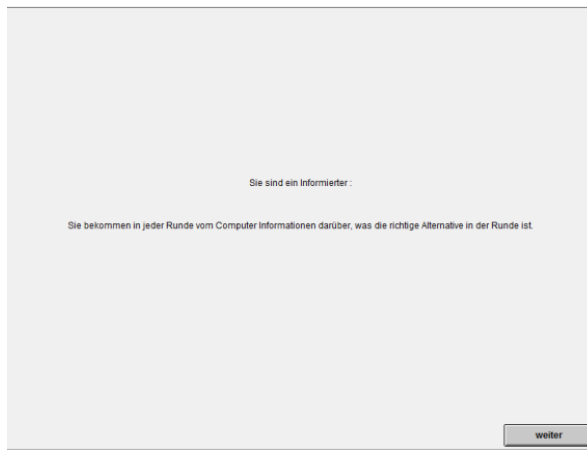
Instructions

In this experiment you will choose along with your group one out of two alternatives whereupon just one alternative is correct and the other is wrong. Only the correct alternative leads to a positive payoff for each member of the group. Some members of the group will receive information about the correct alternative. This information is accurate in 60 out of 100 cases. The group decides by voting which alternative will be implemented. The group is furthermore arranged in a communication network. Certain members of the group can – depending on the network structure – transmit a message to other members before the group ballots for the alternatives.

The sequence of each individual round consists of the following 4 parts.

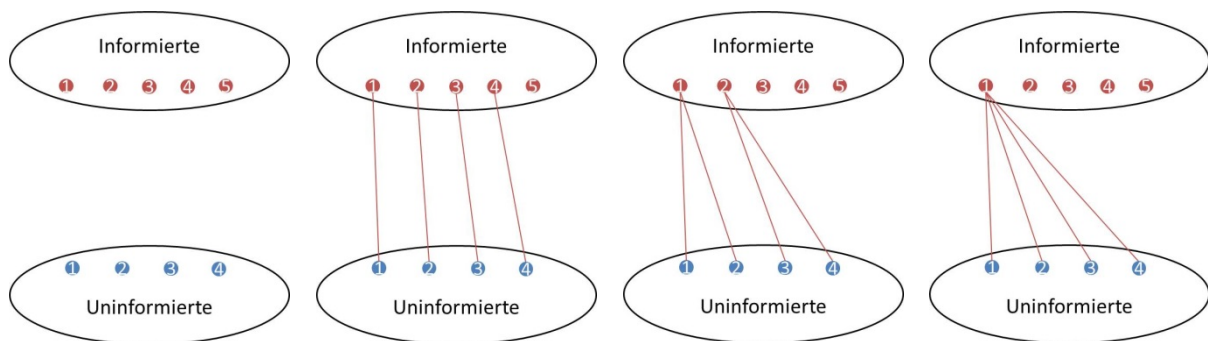
1. Information

You will receive the role of an Informed or an Uninformed at random (and you will keep it during the entire experiment). There are two alternatives: alternative "circle" and alternative "triangle". At the beginning of each round one of the two alternatives will be assigned at random and with equal likelihood as the correct alternative. The "Informed" receive information about the correct alternative which is accurate in 60 out of 100 cases. (The Informed will not necessarily all receive the same information). The "Uninformed" will not receive any information about what the correct alternative is.



2. Communication

You will randomly be divided into groups of 9 members. A group is composed of 5 Informed and 4 Uninformed. All group members are arranged in a communication network. At the beginning of a round you get to know the network structure and your position in the network. You can see the possible networks pictured in the figure below.



5 Informed receive in randomized arrangement the positions *Above 1 to 5* in the network. 4 Uninformed receive in randomized arrangement the positions *Below 1 to 4* in the network. Everyone knows therefore that someone with an upper position is an Informed and that someone with a lower position is an Uninformed. The network structure reveals who can communicate with whom. The Uninformed can be recipients but not senders of a message. The Informed who are in the position of a sender send either the message "circle" or the message "triangle" or they don't send any message to their recipient(s). Each sender can send exactly one message to all of its (his/her) recipients. Not every Informed is necessarily a sender. This depends on the network structure and the network position. The connecting lines between upper and lower positions in the network display who can send a message to whom.

Periode: Probe 2 von 4 Verbleibende Zeit [sec]: 0
Bitte entscheiden Sie sich jetzt!

Sie sind ein Informierter in Netzwerkposition 3.

Ihre Information für diese Runde lautet:
Dreieck ist die richtige Alternative.

Sie sind Sender 3, der eine Nachricht an den Uninformierten 3 schicken kann.

Was möchten Sie tun?
Die Nachricht "Kreis" senden / Die Nachricht "Dreieck" senden / Keine Nachricht senden

Kreis keine Nachricht Dreieck

Periode: Probe 2 von 4 Verbleibende Zeit [sec]: 0

Sie sind ein Informierter in Netzwerkposition 5.

Ihre Information für diese Runde lautet:
Dreieck ist die richtige Alternative.

Sie informieren in dieser Runde keinen uninformatierten Teilnehmer.

weiter

3. Voting

You can decide to vote for “circle,” to abstain from voting, or to vote for “triangle.” The 2 Circle-advocates always vote for “circle” and the 2 Triangle-advocates always for “triangle.” The voting result in the group is the alternative (circle or triangle) with the most votes. In case of a tie the computer will pick one of the two alternatives at random and with the same probability.

Periode: Probe 2 von 4 Verbleibende Zeit [sec]: 0
Bitte entscheiden Sie sich jetzt!

Sie sind ein Uninformierter in Netzwerkposition 4.

Sender 4 schickt Ihnen folgende Nachricht:
Dreieck.

Bitte treffen Sie Ihre Entscheidung:

Kreis Enthaltung Dreieck

Periode: Probe 2 von 4 Verbleibende Zeit [sec]: 0

Sie sind ein Informierter in Netzwerkposition 5.

Ihre Information für diese Runde lautet:
Dreieck ist die richtige Alternative.

Bitte treffen Sie Ihre Entscheidung:

Kreis Enthaltung Dreieck

4. Outcome

At the end of the round you will get to know the voting outcome as well as the right alternative. If they match, e.g. the voting outcome is triangle and the right alternative is triangle, you will receive 100 points. Otherwise you will not receive any points. At the end of 40 rounds 3 rounds will be drawn randomly, which are then relevant for the payoffs. The rate of exchange between points and Euro is the following: 20 points correspond to 1 Euro. You will receive 5 Euro additionally for your participation in the experiment.

Periode	Probe 4 von 4	Verbleibende Zeit [sec]: 25	Periode	Probe 4 von 4	Verbleibende Zeit [sec]: 0
Es haben sich 4 (von 9) Mitgliedern der Gruppe an der Wahl beteiligt. Das Ergebnis der Wahl in der Gruppe lautet: Kreis. Die richtige Alternative war Kreis			Es haben sich 9 (von 9) Mitgliedern der Gruppe an der Wahl beteiligt. Das Ergebnis der Wahl in der Gruppe lautet: Dreieck. Die richtige Alternative war Dreieck		
Ihr Gewinn in dieser Runde wäre 100 Punkte.			Ihr Gewinn in dieser Runde wäre 100 Punkte.		
Weiter			Weiter		

Procedure of the experiment

40 rounds will be played in total. The composition of the group changes from round to round. The network structure changes every 5 rounds. There will be a short questionnaire subsequent to the 40 rounds of the experiment. Prior to the 40 rounds of the experiment 4 sample rounds are played. These are not payoff-relevant. (In each sample round a different network is introduced.)

Summary of the procedure of the experiment:

1. Reading of the instructions
2. Questions of comprehension concerning the instructions
3. 4 sample rounds
4. 40 EXPERIMENTAL ROUNDS
5. Questionnaire
6. Payoffs

If you have a question, please raise your hand from the cabin, we will then come to you.

Comprehension questions

1. Which of the following statements is correct? (Please checkmark)
 - a. The role of the Informed/Uninformed changes from round to round.
 - b. The group affiliation changes from round to round.
 - c. The network changes from round to round.

2. Which of the following statements is correct? (Please checkmark)
 - a. In each round either the alternative „circle“ or the alternative „triangle“ is correct, namely with a probability of 50% no matter which alternative has been most frequently correct in the previous rounds.
 - b. If „triangle“ was 7 times correct in the previous 10 rounds and „circle“ only 3 times, then in the current round it is more likely that „circle“ is correct instead of „triangle“.
 - c. If „circle“ was 7 times correct in the previous 10 rounds and „triangle“ only 3 times, then in the current round it is more likely that „circle“ is correct instead of „triangle“.

3. Which of the following statements is correct? (Please checkmark)
 - a. The „Informed“ in the group know for sure which alternative is correct.
 - b. All „Informed“ in the group share the same opinion about what the correct alternative is.
 - c. Each „Informed“ in the group receives some information about which alternative is correct and this information is accurate in 60 out of 100 cases.

4. Which of the following statements is correct? (Please checkmark)
 - a. Each „Informed“ is a sender.
 - b. Each sender is an „Informed.“
 - c. A sender can be an „Informed“ or an “Uninformed.”

5. Which of the following statements is correct? (Please checkmark)
 - a. If the correct alternative is „circle“ and you vote for circle, you will always receive 100 points.
 - b. If the correct alternative is „circle“ and a majority of the participants vote for circle, you will receive 100 points.
 - c. If the correct alternative is „circle“ and a majority of the participants vote for triangle, you will receive 100 points.

Welcome to today's experiment!

Please note that **no communication** is allowed from now on and during the whole experiment. If you have a question please raise your hand from the cabin, one of the experimenters will then come to you. The use of cell phones, smart phones, tablets, or similar devices is prohibited during the entire experiment. Please note that a violation of this rule leads to exclusion from the experiment and from any payments.

All decisions are taken anonymously, i.e. none of the other participants comes to know the identity of the others. The payoff is also conducted anonymously at the end of the experiment.

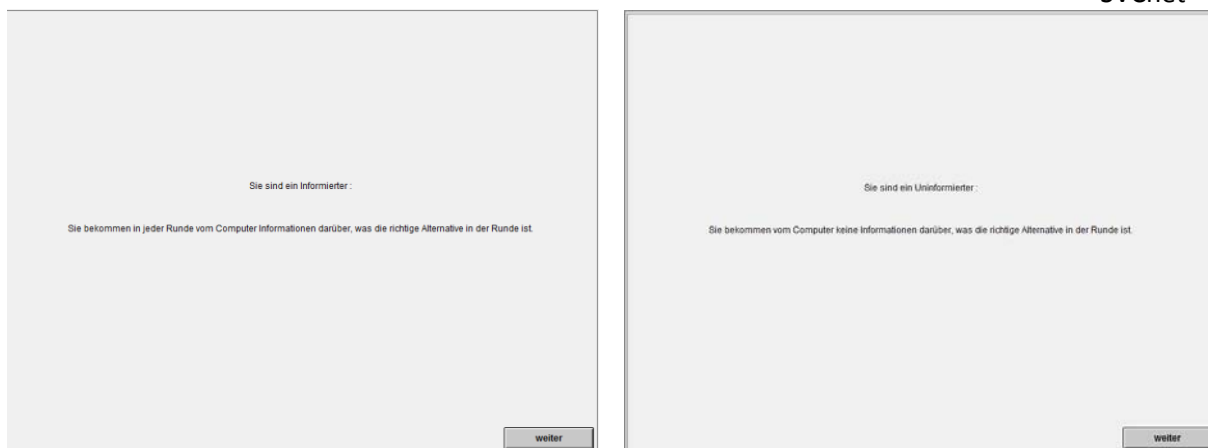
Instructions

In this experiment you will choose along with your group one out of two alternatives whereupon just one alternative is correct and the other is wrong. Only the correct alternative leads to a positive payoff for each member of the group. Some members of the group will receive information about the correct alternative. This information is accurate in 80 out of 100 cases. The group decides by voting which alternative will be implemented. The group is furthermore arranged in a communication network. Certain members of the group can – depending on the network structure – transmit a message to other members before the group ballots for the alternatives.

The sequence of each individual round consists of the following 4 parts.

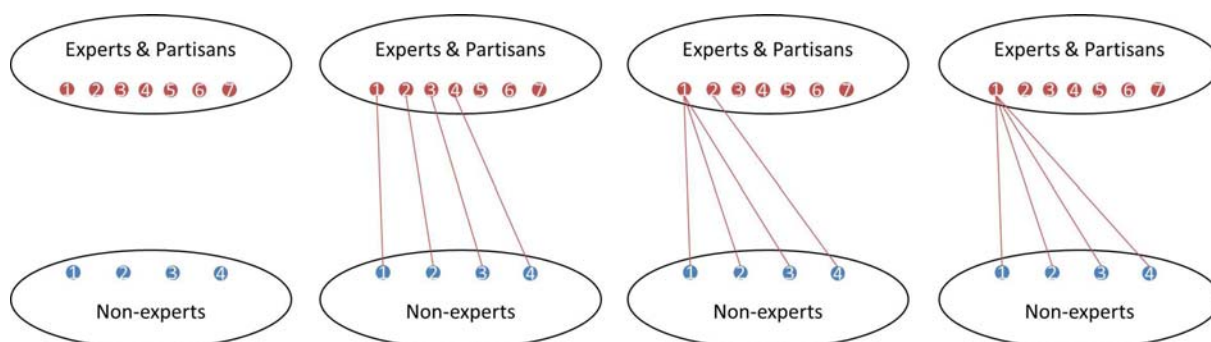
1. Information

You will receive the role of an Informed or an Uninformed at random (and you will keep it during the entire experiment). There are two alternatives: alternative "circle" and alternative "triangle". At the beginning of each round one of the two alternatives will be assigned at random and with equal likelihood as the correct alternative. The "Informed" receive information about the correct alternative which is accurate in 80 out of 100 cases. (The Informed will not necessarily all receive the same information). The "Uninformed" will not receive any information about what the correct alternative is.

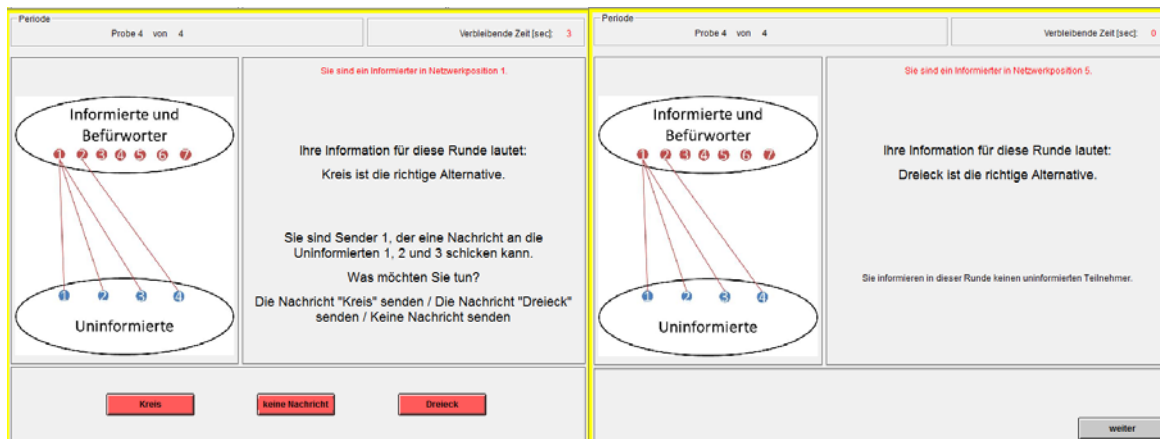


2. Communication

You will randomly be divided into groups of 11 members out of whom 7 are real participants and the remaining 4 being represented by the computer. A group is composed of 3 Informed and 4 Uninformed (a total of 7 real participants of the experiment) as well as 2 Circle-advocates and 2 Triangle-advocates (group members represented by the computer). The Circle-advocates categorically vote for “circle;” and the Triangle-advocates categorically vote for “triangle.” All group members are arranged in a communication network. At the beginning of a round you get to know the network structure and your position in the network. You can see the possible networks pictured in the figure below.

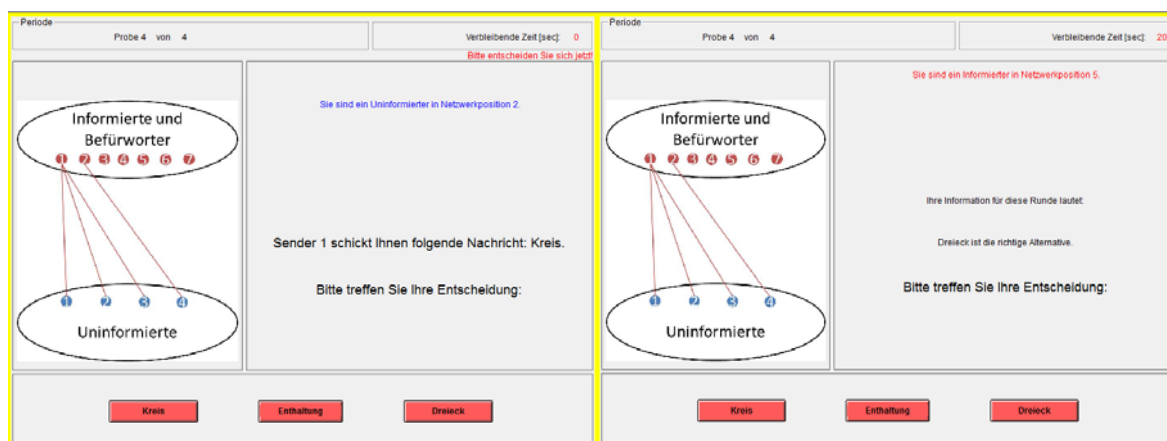


3 Informed and 4 Advocates receive in randomized arrangement the positions *Above 1 to 7* in the network. 4 Uninformed receive in randomized arrangement the positions *Below 1 to 4* in the network. Everyone knows therefore that someone with an upper position is either an Informed or an Advocate and that someone with a lower position is an Uninformed. The network structure reveals who can communicate with whom. The Uninformed can be recipients but not senders of a message. Sender of the message is – depending on the network position – an Informed or an Advocate. The Circle-advocates send the message “circle” to their recipient(s) and the Triangle-advocates send the message “triangle.” The Informed send either the message “circle” or the message “triangle” or they don’t send any message to their recipient(s). Each sender can send exactly one message to all of its (his/her) recipients. Not every Informed or Advocate is necessarily a sender. This depends on the network structure and the network position. The connecting lines between upper and lower positions in the network display who can send a message to whom.



3. Voting

You can decide to vote for “circle,” to abstain from voting, or to vote for “triangle.” The 2 Circle-advocates always vote for “circle” and the 2 Triangle-advocates always for “triangle.” The voting result in the group is the alternative (circle or triangle) with the most votes. In case of a tie the computer will pick one of the two alternatives at random and with the same probability.



4. Outcome

At the end of the round you will get to know the voting outcome as well as the right alternative. If they match, e.g. the voting outcome is triangle and the right alternative is triangle, you will receive 100 points. Otherwise you will not receive any points. At the end of 40 rounds 3 rounds will be drawn randomly, which are then relevant for the payoffs. The rate of exchange between points and Euro is the following: 20 points correspond to 1 Euro. You will receive 5 Euro additionally for your participation in the experiment.

Periode	1 von 40	Verbleibende Zeit [sec]	24
Es haben sich 7 (von 11) Mitgliedern der Gruppe an der Wahl beteiligt. Das Ergebnis der Wahl in der Gruppe lautet: Dreieck. Die richtige Alternative war Dreieck			
Wenn diese Runde für die Auszahlung gezogen wird beträgt Ihr Gewinn 100 Punkte. Weiter			

Periode	1 von 24	Verbleibende Zeit [sec]	2
Es haben sich 11 (von 11) Mitgliedern der Gruppe an der Wahl beteiligt. Das Ergebnis der Wahl in der Gruppe lautet: Kreis. Die richtige Alternative war Kreis			
Wenn diese Runde für die Auszahlung gezogen wird beträgt Ihr Gewinn 100 Punkte. Weiter			

Procedure of the experiment

40 rounds will be played in total. The composition of the group changes from round to round. The network structure changes every 5 rounds. There will be a short questionnaire subsequent to the 40 rounds of the experiment. Prior to the 40 rounds of the experiment 4 sample rounds are played. These are not payoff-relevant. (In each sample round a different network is introduced.)

Summary of the procedure of the experiment:

1. Reading of the instructions
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5. Questionnaire
6. Payoffs

If you have a question, please raise your hand from the cabin, we will then come to you.

Comprehension questions

1. Which of the following statements is correct? (Please checkmark)
 - a. The role of the Informed/Uninformed changes from round to round.
 - b. The group affiliation changes from round to round.
 - c. The network changes from round to round.
2. Which of the following statements is correct? (Please checkmark)
 - a. In each round either the alternative „circle“ or the alternative „triangle“ is correct, namely with a probability of 50% no matter which alternative has been most frequently correct in the previous rounds.
 - b. If „triangle“ was 7 times correct in the previous 10 rounds and „circle“ only 3 times, then in the current round it is more likely that „circle“ is correct instead of „triangle“.
 - c. If „circle“ was 7 times correct in the previous 10 rounds and „triangle“ only 3 times, then in the current round it is more likely that „circle“ is correct instead of „triangle“.
3. Which of the following statements is correct? (Please checkmark)
 - a. In each group there are 2 persons represented by the computer who always vote for “circle” and 2 persons likewise represented by the computer who always vote for “triangle”.
 - b. In each group there are 4 persons represented by the computer who always vote for “circle”.
 - c. In each group there are 4 persons represented by the computer who always vote for “triangle”.
4. Which of the following statements is correct? (Please checkmark)
 - a. The „Informed“ in the group know for sure which alternative is correct.
 - b. All „Informed“ in the group share the same opinion about what the correct alternative is.
 - c. Each „Informed“ in the group receives some information about which alternative is correct and this information is accurate in 80 out of 100 cases.
5. Which of the following statements is correct? (Please checkmark)
 - a. Each „Informed“ is a sender.
 - b. Each sender is an „Informed.“
 - c. A sender can be an „Informed“, a Circle-Advocate or a Triangle-Advocate.
6. Consider a Circle-Advocate who can send a message. Which of the following statements is correct? (Please checkmark)
 - a. The Circle-Advocate always sends the message „circle“.
 - b. The Circle-Advocate sometimes sends the message “triangle.”
 - c. The Circle-Advocate sometimes does not send any message.
7. Which of the following statements is correct? (Please checkmark)
 - a. If the correct alternative is „circle“ and you vote for circle, you will always receive 100 points.
 - b. If the correct alternative is „circle“ and a majority of the participants vote for circle, you will receive 100 points.
 - c. If the correct alternative is „circle“ and a majority of the participants vote for triangle, you will receive 100 points.