COMMUNICATION AMONG VOTERS BENEFITS THE MAJORITY PARTY*

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How does communication among voters affect turnout? In a laboratory experiment, subjects, divided into two competing parties, choose between costly voting and abstaining. Pre-play communication treatments, relative to the no communication control, are public communication (subjects exchange public messages through computers) and party communication (messages are public within one's own party). Communication benefits the majority party by increasing its turnout margin, hence its winning probability. Party communication increases turnout; public communication decreases total turnout with a low voting cost. With communication, there is no support for Nash equilibrium and limited consistency with correlated equilibrium.

How does pre-play communication among economic agents affect collective decisions? Prominent game-theoretic models for situations such as voting, contributing to a public good, multi-lateral bargaining, auctions and entry games, to name a few, typically discard the availability of pre-play communication among the players. They do so, in part, because of an increased complexity of the equilibrium analysis under communication, and, in part, because original equilibria are maintained due to the non-binding nature of pre-play communication. Many experimental studies show, however, that pre-play communication can have significant effects on outcomes in many different settings (e.g., Palfrey and Rosenthal, 1991; Cooper *et al.*, 1992; Agranov and Tergiman, 2014; Agranov and Yariv, 2015; Palfrey *et al.*, 2015).

In this article, we attempt to explore the general principles behind pre-play communication in a laboratory experiment on voter turnout, an application that combines features of free-riding and team competition. The game is very simple: two groups of voters of commonly known different sizes (think political parties) compete against each other in a winner-take-all election under the plurality rule. Voters simultaneously decide on a binary choice: vote or abstain. Voting is costly, with a commonly known cost of voting that is the same for all voters.

In the turnout game without communication, each player decides whether or not to vote independently of others. The game-theoretic analysis of this case (Palfrey and Rosenthal, 1983) shows that, generally, there will be either one or two quasi-symmetric

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Nash equilibria, in which all members of the same party mix with the same probability of voting. There are also asymmetric equilibria, which we do not consider here, as they are logically implausible without a device to break symmetries (see Kuzmics and Rogers, 2010; Alós-Ferrer and Kuzmics, 2013).

With communication, the formal structure of the turnout game changes dramatically, as individual turnout decisions can now be correlated. Allowing for correlation greatly expands the set of equilibria. In fact, the game with unrestricted communication admits an infinite number of equilibria, with expected total turnout ranging between nearly zero and twice the size of the minority party for all positive voting costs, such that abstention is not a dominant strategy (Pogorelskiy, 2017).

We study the effects of unmediated pre-play communication on turnout. Before making their decisions, subjects engage in free-form communication by broadcasting computer chat messages to subsets of players. We consider two cases: public communication, where players can exchange public messages visible to all participants; and party communication, where players can exchange messages that are public only within their own party (majority or minority). These communication protocols have broad analogs to communication that occurs in real elections. For example, car bumper stickers can be interpreted as public messages, while Facebook status updates, visible only to one's own group of friends or social connections, are examples of group-based public messages.[1]

A refinement of correlated equilibrium, subcorrelated equilibrium is used to characterise the equilibria with party communication (Pogorelskiy, 2015). While our experiment (and the model) does not have any explicit centralised mobilisation efforts *per se*, one can view the kind of decentralised communication studied here as corresponding to neighbourhood information exchanges (Großer and Schram, 2006), conversations and interactions with family and friends or communication via social media.[2]

In addition to the communication treatment, the experiment varies two other crucial parameters of the model: the voting cost ('low' cost *versus* 'high' cost) and the relative party sizes (large *versus* small minority). This leads to a $3 \times 2 \times 2$ design with a total of 12 different treatments. A novel feature of this study is the sensitivity of turnout to changes in these parameters under our restrictions on communication, which allows us to identify interaction effects between communication mode and key parameters of the theoretical model.

The main finding of the experiment is that communication affects turnout for the majority and minority parties in much different ways. Specifically, communication benefits the majority party, as it increases the expected turnout margin relative to no communication, and hence, increases the expected margin of victory for the majority and the probability of the majority winning. The finding is unambiguous, robust and quite strong. We observe it in all treatments, for both communication protocols, both low

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[1] Bond *et al.* (2012) studied effects of a very influential group-based message in a turnout setting featuring the 'I Voted' button on top of Facebook users' newsfeed.

[2] Field experimental studies, which usually isolate a particular communication mechanism, have shown significant but mixed evidence (Gerber and Green, 2000; Gerber *et al.*, 2011), which is perhaps not surprising, given the variety of different ways in which people communicate. Effectiveness of political communication depends on complex interactions of different communication mechanisms, political actors, and institutional structures (Druckman, 2014).

and high voting costs, and both large and small majorities. Furthermore, in almost all cases, the effects are statistically significant and large in magnitude. This result is not only strong, but also surprising (at least to us), in the sense that it is not predicted by any theoretical model of which we are aware, including our correlated and sub-correlated equilibrium models.[3]

The experiment also generates three other findings that complement this main finding.

First, the communication design of the experiment allows us to test the consistency of experimental data under communication with correlated equilibrium. Although correlated equilibria have been largely ignored in the experimental study of pre-play communication, they are particularly well suited for the analysis of such games.[4] This is especially the case with our design, as it includes both public and party communication mechanisms, which require somewhat different variations in the correlated equilibrium concept. We design several new tests to check for the consistency with correlated equilibrium and find that voting cost plays an important role here: with low cost and group communication, we cannot reject the hypothesis that the data are generated by a correlated equilibrium, while with high cost, this is no longer the case for either communication treatment. On the other hand, in almost all communication treatments, we reject the hypothesis that voters' individual decisions are independent, implying no support for Nash equilibrium under communication.

Second, we identify an interaction effect between the structure of communication and the cost of voting. Party communication increases total turnout. With a low voting cost, public communication decreases total turnout. With a high voting cost, public communication does not significantly affect total turnout. Thus, we identify a cost/communication interaction effect, whereby cost considerations appear to be an important factor in participation decisions under communication, which ties in with some existing empirical results (Brady and McNulty, 2011; Hodler and Stutzer, 2015). Surprisingly, public communication, at an election stage where voters' preferences have already been formed, can be detrimental to getting out the vote.

Third, we find that turnout rates are affected by the voting cost and election competitiveness. Theoretically, turnout in each party is higher when costs are lower. We observe this cost effect in all treatments, except with public communication. We also observe positive effects of *ex ante* election competitiveness on turnout (as measured by the relative party sizes), holding the other treatment dimensions constant.[5]

The remainder of the article is organised as follows. In Section 1, we provide a brief literature review. Section 2 lays out the theoretical model of voter turnout, including formal definitions of correlated and subcorrelated equilibrium as it applies

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[3] The theoretical model of Denter and Sisak (2015) shows that, under certain conditions, perfect polls (a restricted form of communication) can create momentum in favour of the front-running candidate. The underlying mechanism, however, is totally different, as in their model, two candidates strategically choose investments in their political campaigns, trying to influence the decisive voter's probabilistic choice.

[4] A notable exception is Moreno and Wooders (1998). See also Cason and Sharma (2007) and Duffy and Feltovich (2010) for studies of abstract games with recommended play.

[5] The cost and competition effects have support from other experiments (Levine and Palfrey, 2007; Herrera *et al.*, 2014; Kartal, 2015).

the voter turnout game. In Section 3, we describe the details of our experimental design. Section 4 presents our findings at the electorate level and party level. Section 5 concludes. Additional estimation details are in online Appendix A. Experimental instructions are in online Appendix B. Experimental data and programs are available online.

1. Related Literature

Several studies have investigated the effects of restrictive communication mechanisms – such as neighbourhood information exchange and polls – on voter turnout. Großer and Schram (2006) consider the effects of communication in the form of neighbourhood information exchange. In their model, every two voters form a neighbourhood, with one being an early voter (sender) and one a late voter (receiver). They find that information exchange increases turnout, although these results seem to be sensitive to the analysed sender–receiver protocol. Großer and Schram (2010), and Agranov et al. (2017) study the effects of polls on turnout and welfare in the laboratory.[6] In particular, Agranov et al. (2017) show that polls do not have negative welfare effects.

More relevant to the current article, the authors also find evidence for voting with the winner, where a voter is more likely to turn out if she thinks that her preferred candidate is more likely to win. While this ties in nicely with our main finding that communication benefits the majority party by increasing its expected margin of victory, the environment, the communication mechanism and the results of the two articles differ in important ways. Concerning the difference in environments, Agranov et al.'s (2017) explores information revelation in a game with uncertainty about the distribution of preferences. Voters have incomplete information and private signals about the number of voters favouring each candidate. Prior to polling, voters do not even know whether or not they are in the majority party, and polls serve as an information aggregation device to reveal simultaneously to all voters the relative sizes of the two candidates' support in the electorate. By contrast, this study focuses on an environment where the number of voters favouring each candidate is common knowledge among all the voters from the very start of the game, so communication can only serve as a coordination device to allow for correlation in the turnout decisions of the voters; no actual information is transmitted. Concerning the difference in mechanism, the communication technology in Agranov et al. (2017) is very limited, being only a poll, where each voter sends a vote message to the experimenter, and then only the aggregate vote count in the poll is reported back to all voters. By contrast, our subjects use a free-form computerised chat with public (i.e. multi-way) messages that serve as a coordination device. In our group-communication treatment, voters from different parties communicate through separate chats, so communication is partially private. The results are also different. They find that

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[6] Morton et al. (2015), in a natural experiment, estimate that exit polls decrease turnout and increase bandwagon voting. Theoretical models of polls include McKelvey and Ordeshook (1985) and Denter and Sisak (2015).

information transmission with polls increases majority participation rates but decreases minority turnout rates. The effects move turnout rates in opposite directions, mobilising both a positive (for the majority) and a negative (for the minority) bandwagon, triggered by the revelation of the true distribution of voter preferences. While we observe this effect in some of our treatments, we find that in other treatments, communication affects participation rates in both parties in the same direction, with the effect on majority party turnout being relatively stronger (when both parties' turnout rates increase), and relatively weaker (when both parties' turnout rates decrease).

In theory, pre-play communication can replicate the effects of both polls and neighbourhood information exchanges. Schram and Sonnemans (1996b) study Schram and van Winden's (1991) social pressure turnout model in the laboratory. There are two groups, each with opinion leaders who produce social pressure on others to turn out. One of the basic predictions of that model, that communication increases turnout, is supported by the data. In their experiment, for five minutes, there was oral communication among the members of the same group, after which five more rounds of the game without further communication were played. This is different from having pre-play communication in each round, as in our article.

Another related article is Kittel et al. (2014). They study three-party elections with costly voting, varying voter preference types (swing voters, who have strict rankings over three parties, versus partisans, who strictly prefer one party but are indifferent between the two less preferred ones); party labels; and pre-play communication protocol (public across groups versus public within groups, as in our experiment). Kittel et al. (2014) find that communication increases both turnout and the amount of strategic voting. The effects of the communication protocol on turnout depend on voter preferences and are nuanced. In particular, swing voters and partisans show different turnout rates: swing voters assigned to their second choice are more likely to turn out in the 'all-chat' than in the 'party-chat', while swings assigned to their first choice, as well as partisans, show no difference. While we use similar communication treatments, our results are not directly comparable since three-party elections introduce a completely different motive for voting, and introduce additional strategic considerations.[7]

2. The Model

In this Section, we provide some theoretical background for the pivotal-voter model of Palfrey and Rosenthal (1983) on which our experiment builds. There is a set of voters N with $|N| = n$, divided into two parties, N_A and N_B, with a number of supporters $n_A > n_B = n - n_A > 0$. Voters in each party decide between voting for their respective party (action 1) or abstaining (action 0). Each player i's action space is $S_i = \{0, 1\}$. The

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[7] Several strands of the literature are less related to our article. One studies the effects of deliberation on jury voting, where abstention is not allowed (Guarnaschelli et al., 2000; Goeree and Yariv, 2011). Another studies the performance of the rational turnout models in the laboratory but without communication among voters (Schram and Sonnemans, 1996a; Levine and Palfrey, 2007; Duffy and Tavits, 2008; Herrera et al., 2014; Kartal, 2015). There are also studies of communication within and between teams in team contests in which members choose individual effort levels that determine the joint team output. See, in particular, Sutter and Strassmair (2009), who find that within-team communication increases average effort levels. Balliet (2010) surveys studies of communication in social dilemmas with a focus on the prisoner's dilemma.

set of joint voting profiles is $S = S_1 \times \ldots \times S_n$, i.e. $S = \{(s_i)_{i \in N} | s_i \in \{0, 1\}\}$; and the set of all probability distributions over S is $\Delta(S)$. Player i's utility at an action profile (s_i, s_{-i}) is denoted $\mathcal{U}_i(s_i, s_{-i})$; and her expected utility from s_i given the belief about others' actions σ_{-i} is $U_i(s_i, \sigma_{-i}) \equiv \mathbb{E}_{\sigma_{-i}} \mathcal{U}_i(s_i, \cdot)$. The election is decided by a simple plurality rule, with ties broken randomly. Voting is costly, with $c \in (0, 1/2)$ being the common voting cost. Each player i's utility is normalised to 1 if her preferred party wins, $1/2$ if there is a tie, and 0 otherwise, minus the voting cost, if i decides to vote. The game has complete information, and the only uncertainty from a player's point of view comes from not knowing what, exactly, everybody else is going to choose. Each voter would ideally prefer her party to win the election without her actually voting, so the game combines a free-rider problem with a collective action problem in each party. Rational voters trade off the expected benefits from voting against the cost, so the probability of their vote changing the election outcome is the key factor. In an equilibrium, this so-called pivot probability is determined endogenously.

In a *quasi-symmetric* Nash equilibrium (NE), each player i who prefers party N_j, $j \in \{A, B\}$, mixes between voting for j and abstaining with the same probability $q = q_j$ conditional on the party, and given these strategies, each player must be indifferent between the two actions: $U_i(0, q_{-i}) = U_i(1, q_{-i})$. The equilibrium voting probabilities are determined from the following two equations:

$$2c = \Pr(i \in N_A \text{ is pivotal}), \tag{1}$$

$$2c = \Pr(i \in N_B \text{ is pivotal}). \tag{2}$$

Expressing the pivotal probability via equilibrium voting probabilities q_A and q_B, we obtain:

$$2c = \sum_{a=0}^{n_B} \binom{n_A - 1}{a} \binom{n_B}{a} q_A^a (1 - q_A)^{n_A - 1 - a} q_B^a (1 - q_B)^{n_B - a}$$

$$+ \sum_{a=0}^{n_B - 1} \binom{n_A - 1}{a} \binom{n_B}{a + 1} q_A^a (1 - q_A)^{n_A - 1 - a} q_B^{a+1} (1 - q_B)^{n_B - a - 1}, \tag{3}$$

$$2c = \sum_{b=0}^{n_B - 1} \binom{n_A}{b} \binom{n_B - 1}{b} q_A^b (1 - q_A)^{n_A - b} q_B^b (1 - q_B)^{n_B - 1 - b}$$

$$+ \sum_{b=0}^{n_B - 1} \binom{n_A}{b + 1} \binom{n_B - 1}{b} q_A^{b+1} (1 - q_A)^{n_A - b - 1} q_B^b (1 - q_B)^{n_B - 1 - b}. \tag{4}$$

In both equations, the first sum on the right-hand side is the equilibrium probability of a single vote to make a tie, the second is the equilibrium probability of a single vote to break the tie in favour of the preferred party. Probabilities of a tie and near tie (i.e. a tie ± one vote) provide a measure of the expected closeness of the election, as well as the probability of the minority party winning (the upset rate), which affects a measure of social welfare. The equilibrium logic leads from the primitives of the model (party sizes and voting cost) to predictions about these probabilities and about the turnout rates in

each party and in the whole electorate.[8] The equilibrium probability of a joint voting profile with a total votes for N_A and b total votes for N_B is

$$\nu(a, b) \equiv \binom{n_A}{a}\binom{n_B}{b} q_A^a (1 - q_A)^{n_A - a} q_B^b (1 - q_B)^{n_B - b}. \tag{5}$$

A *correlated equilibrium* (CE), developed in Aumann (1974, 1987), is a probability distribution over joint action profiles such that at every profile, each player's choice is a best response under the posterior distribution conditional on that choice. Formally, a correlated equilibrium is $\mu \in \Delta(S)$ such that for all $i \in N$, s_i, $s_i' \in S_i$:

$$\sum_{s_{-i} \in S_{-i}} \mu(s_i, s_{-i}) \left[\mathcal{U}_i(s_i, s_{-i}) - \mathcal{U}_i(s_i', s_{-i}) \right] \geq 0. \tag{6}$$

In a CE of the turnout game, unlike Nash equilibrium, there are two best response conditions for each player: conditional on deciding to vote, and conditional on deciding to abstain. Every CE, μ, is defined by the following $2n$ inequalities (in addition to the standard probability constraints) for each $i \in N$:

$$\Pr(i \text{ is pivotal} \mid i \text{ abstains}; \mu) \leq 2c,$$

$$\Pr(i \text{ is pivotal} \mid i \text{ votes}; \mu) \geq 2c.$$

The main difference between NE and CE is that in the latter, players' strategies can be correlated, while in a Nash equilibrium, all players decide whether to vote or abstain independently. Thus, every Nash equilibrium is also a correlated equilibrium, but (in a formal sense) almost all correlated equilibria of the turnout game are not Nash equilibria. Using the formula for conditional probability, each pair of CE inequalities can be simplified:

$$\frac{\frac{1}{2} - c}{c} \Pr(i \text{ is pivotal \& abstains} | \mu) \leq \Pr(i \text{ is non-pivotal \& abstains} | \mu), \tag{7}$$

$$\frac{\frac{1}{2} - c}{c} \Pr(i \text{ is pivotal \& votes} | \mu) \geq \Pr(i \text{ is non-pivotal \& votes} | \mu). \tag{8}$$

To check consistency with a correlated equilibrium, we need frequency estimates of the joint turnout profiles from the data. The number of such profiles in a n-person electorate is 2^n, making it infeasible to estimate frequencies with our data. To circumvent this problem, we reduce the number of joint profiles to a manageable size by combining all the profiles that have the same number of votes from each party and differ only by the identity of those voting and abstaining. This reduction implicitly assumes that such profiles are equally likely. For example, we assume that the following profiles have equal probability: a profile with all of the minority voting and with voters 1, 2 and 3 of the majority voting; and a profile with all of the minority voting and with voters 4, 5 and 6 of the majority voting. To state this assumption formally, let $\mu(z_i, a, b)$ denote the probability of any joint profile where player i plays strategy z_i, and, among the other $n - 1$ players, a players turn out in group N_A and b players turn out in group N_B (where

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[8] There are other, asymmetric Nash equilibria in this class of games – see Palfrey and Rosenthal (1983) – but our experimental design makes them infeasible to sustain.

'groups' correspond to the majority and minority party, respectively, in the context of our experiment).

ASSUMPTION 1. (*Group-symmetric distributions*). *We consider only distributions over joint voting profiles that satisfy the following restrictions:*

$$\forall i \in N_A, \forall a \in \{1, \ldots, n_A - 1\}, \forall b \in \{0, \ldots, n_B\}: \ \mu(0_i, a, b) = \mu(1_i, a - 1, b),$$

$$\forall k \in N_B, \forall b \in \{1, \ldots, n_B - 1\}, \forall a \in \{0, \ldots, n_A\}: \ \mu(0_k, a, b) = \mu(1_k, a, b - 1).$$

Applying Assumption 1, we now have a total of $(n_A + 1)(n_B + 1)$ different profiles for which frequencies can be estimated from the data. We can now simply write

$$\binom{n_A}{a} \binom{n_B}{b} \mu_{a,b}$$

for the probability of a joint profile with a votes from party N_A and b votes from party N_B (cf. Nash-induced joint probability $\nu(a, b)$ in (5)). For a group-symmetric correlated equilibrium, conditions (7–8) can be simplified (Pogorelskiy, 2017) and written as a system of four inequalities: two for a player in N_A, and two for a player in N_B, with respect to $(n_A + 1)(n_B + 1)$ unknowns, $\mu_{a,b}$:

$$\frac{\frac{1}{2} - c}{c} \left[\sum_{a=0}^{n_B} \binom{n_A - 1}{a} \binom{n_B}{a} \mu_{a,a} + \sum_{a=0}^{n_B - 1} \binom{n_A - 1}{a} \binom{n_B}{a + 1} \mu_{a,a+1} \right] \leq$$

$$\sum_{a=1}^{n_A - 1} \sum_{b=0}^{\min\{a-1, n_B\}} \binom{n_A - 1}{a} \binom{n_B}{b} \mu_{a,b} + \sum_{a=0}^{n_B - 2} \sum_{b=a+2}^{n_B} \binom{n_A - 1}{a} \binom{n_B}{b} \mu_{a,b}, \tag{9}$$

$$\frac{\frac{1}{2} - c}{c} \left[\sum_{a=0}^{n_B} \binom{n_A - 1}{a} \binom{n_B}{a} \mu_{a+1,a} + \sum_{a=1}^{n_B} \binom{n_A - 1}{a - 1} \binom{n_B}{a} \mu_{a,a} \right] \geq$$

$$\sum_{a=2}^{n_A} \sum_{b=0}^{\min\{a-2, n_B\}} \binom{n_A - 1}{a - 1} \binom{n_B}{b} \mu_{a,b} + \sum_{a=1}^{n_B - 1} \sum_{b=a+1}^{n_B} \binom{n_A - 1}{a - 1} \binom{n_B}{b} \mu_{a,b} \tag{10}$$

and

$$\frac{\frac{1}{2} - c}{c} \left[\sum_{a=0}^{n_B - 1} \binom{n_A}{a} \binom{n_B - 1}{a} \mu_{a,a} + \sum_{a=0}^{n_B - 1} \binom{n_A}{a + 1} \binom{n_B - 1}{a} \mu_{a+1,a} \right] \leq$$

$$\sum_{a=2}^{n_A} \sum_{b=0}^{\min\{a-2, n_B-1\}} \binom{n_A}{a} \binom{n_B - 1}{b} \mu_{a,b} + \sum_{a=0}^{n_B - 2} \sum_{b=a+1}^{n_B - 1} \binom{n_A}{a} \binom{n_B - 1}{b} \mu_{a,b}, \tag{11}$$

$$\frac{\frac{1}{2} - c}{c} \left[\sum_{a=0}^{n_B - 1} \binom{n_A}{a} \binom{n_B - 1}{a} \mu_{a,a+1} + \sum_{a=1}^{n_B} \binom{n_A}{a} \binom{n_B - 1}{a - 1} \mu_{a,a} \right] \geq$$

$$\sum_{a=2}^{n_A} \sum_{b=1}^{\min\{a-1, n_B\}} \binom{n_A}{a} \binom{n_B - 1}{b - 1} \mu_{a,b} + \sum_{a=0}^{n_B - 2} \sum_{b=a+2}^{n_B} \binom{n_A}{a} \binom{n_B - 1}{b - 1} \mu_{a,b}. \tag{12}$$

Pogorelskiy (2017), in an analysis of correlated equilibria in turnout games, characterises the bounds of the set of CE in these games. In particular, CE can have total expected turnout of up to twice the size of the minority party when the minority is large (i.e. the minority's size is at least 50% that of the majority), and up to the majority size in the remaining, small minority, case. Such turnout rates are generally higher than in a quasi-symmetric Nash equilibrium. CE presume unrestricted communication among all players.

A *subcorrelated* equilibrium (SCE), proposed in Pogorelskiy (2015), is a correlated equilibrium with additional restrictions on the structure of admissible correlations. Formally, a SCE is defined relative to a partition of the set of players into K disjoint groups, $\Pi = \{N_1, \ldots, N_k, \ldots, N_K\}$, and is given by a distribution on strategy profiles $\mu \in \Delta(S)$ that satisfies the incentive constraints given by (6), such that μ is generated by K independent probability distributions, each over its respective group sub-profiles. That is, the joint distribution, μ is decomposable as a product of K distributions: there exist $(\gamma_1, \ldots, \gamma_K)$ with $\gamma_k \in \Delta(S^k)$ such that:

$$\mu(s) = \prod_{k=1}^{K} \gamma_k(s|N_k), \tag{13}$$

for all $s \in S$, where $s|N_k := [(s_i)_{i \in N_k}]$ is group N_k's action sub-profile in profile s.

Thus, subcorrelated equilibrium nests both Nash equilibrium and correlated equilibrium as extreme special cases: In the definition of a correlated equilibrium, $K = 1$; and in a Nash equilibrium, $K = N$. Note that every subcorrelated equilibrium is also a correlated equilibrium, just as every Nash equilibrium is a correlated equilibrium, and finer partitions (weakly) reduce the set of subcorrelated equilibria by imposing additional decomposability constraints. For the turnout game, we consider the subcorrelated equilibria defined by the two groups ($K = 2$) corresponding to the majority and minority parties. Thus, in this setting SCE requires that the joint distribution over all-electorate voting profiles is a CE that is also a product of the two mixed party turnout distributions, one for each party. Thus, in a subcorrelated equilibrium, votes can be correlated within, but not across the two parties, implicitly capturing a restriction that any communication between voters takes place within parties.

The effect of this constraint depends on the size of the minority (Pogorelskiy, 2017). With a sufficiently large minority, one can limit communication in this way (i.e. to remain unrestricted only within each party) and still get twice the size of the minority as the theoretical upper bound on the expected total turnout. In contrast, the decomposability restriction of independence across parties is binding in the small minority case and implies an upper bound with lower turnout than in CE.

3. Experimental Design

3.1. *Experimental Treatments and Theoretical Predictions*

In the experiment, we vary the sizes of the parties, n_A and n_B, the common voting cost c, and the communication protocol. The last factor is especially important, because communication allows voters' actions to be correlated, which can, in theory, lead to higher turnout than predicted by the standard Nash equilibria.

Table 1

Theoretical Values for Equilibria with Maximal Total Expected Turnout

n_A	n_B	c	T_A	T_B	T	Tie	Pivot	Upset	Margin
Nash quasi-symmetric									
6	4	0.1	0.625	0.375	0.525	0.089	0.298	0.083	0.428
–	–	0.3	0.161	0.253	0.198	0.322	0.781	0.518	−0.023
7	3	0.1	0.521	0.479	0.508	0.098	0.319	0.009	0.435
–	–	0.3	0.147	0.380	0.217	0.310	0.773	0.545	−0.052
Subcorrelated equilibria									
6	4	0.1	0.667	1.000	0.800	0.200	0.636	0.365	0.000
–	–	0.3	0.667	1.000	0.800	0.600	0.790	0.421	0.000
7	3	0.1	0.725	0.482	0.652	0.096	0.278	0.048	0.556
–	–	0.3	0.544	0.799	0.620	0.479	0.691	0.240	0.227
Correlated equilibria									
6	4	0.1	0.667	1.000	0.800	0.200	0.636	0.365	0.000
–	–	0.3	0.667	1.000	0.800	0.600	0.790	0.421	0.000
7	3	0.1	0.831	0.296	0.670	0.059	0.335	0.030	0.735
–	–	0.3	0.591	0.716	0.628	0.429	0.764	0.215	0.317

Note. There are other correlated equilibria with smaller total turnout, and a low-turnout quasi-symmetric Nash equilibrium that are not listed here.

The above considerations led us to implement the following $2 \times 2 \times 3$ design: large minority ($n_A = 6$, $n_B = 4$) *versus* small minority ($n_A = 7$, $n_B = 3$); high cost ($c = 0.3$) *versus* low cost ($c = 0.1$); and three communication treatments. With respect to communication, the three treatments were: no communication (NC); public communication (PC), where players communicate prior to playing the turnout game by exchanging public messages visible to all participants; and group-restricted public communication (GC), where players can exchange messages that are visible only to other members of their own group/party.

Table 1 summarises equilibria with maximal expected turnout. The table shows the maximum expected turnout rates for quasi-symmetric Nash,[9] correlated and subcorrelated equilibria, for the four treatments in the party-size/voting-cost domain, as well as relevant equilibrium probabilities. We denote by T_A (T_B) the expected equilibrium turnout rate in party A (B); T is the expected total turnout rate; *Tie* is the probability of a tie, *Pivot* is probability of a pivotal event (defined as *tie* $\pm$ one vote); *Upset* is the probability of the minority party winning (upset rate); and *Margin* is the expected margin of victory for party A. It is defined as

$$\text{Margin} = \frac{n_A T_A - n_B T_B}{n_A T_A + n_B T_B}. \tag{14}$$

Note that *Pivot* and *Tie* are total probabilities of the respective joint vote profiles rather than individual-specific probabilities of a single vote making or breaking a tie; e.g. in the case of $n_A = 7$ and $c = 0.1$, these probabilities in the turnout-maximising SCE are slightly lower than in a quasi-symmetric NE (cf. respective rows in Table 1). Despite

[9] Given the anonymous random matching and the symmetric structure of the game for each party, we limit attention to Nash equilibria in which all members of the party mix with the same probability. This is standard in the analysis of data from turnout experiments: e.g. Schram and Sonnemans (1996*a*); Agranov *et al.* (2017). Other kinds of highly asymmetric Nash equilibria are discussed in Palfrey and Rosenthal (1983).

this, the expected total turnout rate is higher in the SCE. The reason is that in the SCE, individual turnout probabilities are correlated within each party, so each individual faces potentially different (weaker) incentive constraints than in NE.

Table 1 shows several patterns of the theoretical equilibrium properties across treatments. We emphasise those regarding the total turnout[10] in the following proposition.

PROPOSITION 1.   *In equilibria that maximise expected turnout under our parameters, the total turnout rate is:*

(*i*) *weakly increasing with correlation in voters' actions (from a Nash to a Subcorrelated to a Correlated equilibrium);*

(*ii*) *increasing in ex ante election competitiveness, except under high voting cost in the quasi-symmetric Nash equilibrium; and*

(*iii*) *weakly decreasing in the voting cost.*

3.2. *Procedures*

We ran a total of 10 sessions with a high common cost ($c = 0.3$) and another 10 sessions with a low common cost ($c = 0.1$), with the main focus on the effects of communication. For each cost, there were two sessions of NC and four sessions each of the two communication treatments: GC, and PC. We used a within-subjects design for the relative size treatment in each session, and we recruited 20 subjects per session to mitigate the effects of shared histories in the presence of communication. The same communication mode (NC, GC or PC) was used throughout the entire session. No subject participated in more than one session. For communication treatments, we limited the duration of chat to 110 seconds.[11]

Each session consisted of 20 'matches', divided into two parts with 10 matches (which we will interchangeably refer to as rounds) in each part. In each match, players in the majority and the minority group were asked to decide whether to abstain or to vote for their party's candidate, knowing the common voting cost. To avoid possible experimenter demand effects, no voting context was mentioned.[12] Majority and minority parties were called 'type A' and 'type B', respectively. Subjects chose between two abstract options, *X* and *Y*, which corresponded to voting and abstention, respectively. The voting cost was implemented as an opportunity cost (i.e. choosing option *Y* would result in a bonus payoff equal to *c*). An example of the user interface is shown in Figure A1 in online Appendix A. Sample instructions, which were read aloud by the experimenter, are in online Appendix B.

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[10] One should note that different solution concepts in Table 1 make equilibrium predictions at different levels: quasi-symmetric NE pins down individual turnout probabilities, conditional on their party, SCE pins down party-specific turnout rates (individual turnout probabilities within a party may be correlated), and CE pins down the total turnout rate (individual turnout probabilities both within and across parties may be correlated. For $n_A = 6$, both SCE and CE achieve the same maximal expected total turnout, so party-restricted correlation in SCE has no bite). Furthermore, there may be multiple equilibria with the same expected turnout. Therefore, we use total turnout rates to make aggregate predictions that are comparable. To check consistency of the data with theory, we use frequency distributions over joint vote profiles rather than a single summary statistic.

[11] When analysing chat logs, it was clear that this amount of time was more than enough for meaningful communication.

[12] Levine and Palfrey (2007) conducted experiments with both neutral and 'election' contexts and found no significant difference in behaviour.
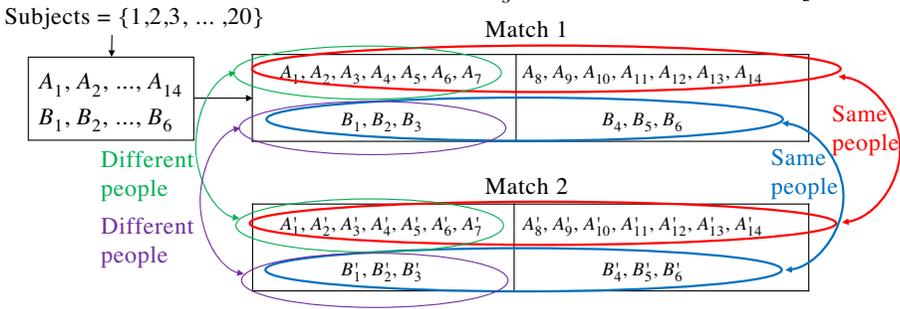
Fig. 1. *Assignment to Parties and Electorates in Part 1 (Example for (7,3) Size Treatment)*
Notes. 20 subjects are first randomly assigned into a majority pool of 14 and minority pool of 6 members; each subsequent match each pool is randomly split into two 10-person electorates comprising seven members from *A* and three members from *B*. Colour figure can be viewed at https://academic.oup.com/ej.

Subjects were randomly assigned to parties and electorates according to the following algorithm. At the beginning of part 1, all subjects were randomly assigned one of the two possible types, which split the session participants into majority and minority pools. For example, if part 1 had relative party sizes of (7,3) and there were 20 subjects in the session, 14 of these subjects were randomly selected to be in the majority pool, and the remaining six subjects were assigned to the minority pool. Next, in the first match of part 1, two 10-voter electorates were created by randomly assigning seven subjects from the majority pool and three subjects from the minority pool to form one of these electorates, with the remaining subjects forming the second electorate. This electorate assignment step was carried out at the beginning of each of the 10 matches of part 1 and was independent across matches. Thus, for the 10 matches of part 1, the assignment of subjects to the party pools remained unchanged, but the assignment to one of the two ten-voter electorates was randomly shuffled after every match (see Figure 1). At the beginning of part two, the subjects were informed that relative party sizes were different. (In this example, the relative party sizes in part two would be (6,4).) Subjects were then randomly reallocated into the two party pools in the following way. All subjects from the former minority pool were assigned to the new majority party pool, with the remaining members of the new majority party pool assigned randomly from the previous majority pool. A former minority subject's new assignment to a party pool was fixed throughout the 10 matches in part 2; a former majority subject's new assignment to a party pool was determined randomly at the beginning of each match.

We chose this scheme to mitigate the inherent inequality of payoffs across subjects since, in either size treatment, the majority was more likely to win.[13] Subjects' IDs within their party were randomly re-assigned every round. In communication treatments, each message contained information about the sender's ID and party, so public messages from different subjects could be clearly distinguished.

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[13] We encountered a minor software issue once when switching to part 2 in two sessions ((7,3)(6,4), high cost and either PC or GC). The resulting session protocol violation was that not all of the minority voters in part 1 might have been switched to the majority in part 2. There were no other violations, and we do not view this as an issue for the analysis.

Table 2

Session Summary

Communication	Session	Cost $c = 0.1$		Session	Cost $c = 0.3$	
		First 10 rounds	Last 10 rounds		First 10 rounds	Last 10 rounds
Group chat	1	(6,4)	(7,3)	2	(6,4)	(7,3)
	3	(7,3)	(6,4)	4	(7,3)	(6,4)
	5	(6,4)	(7,3)	6	(6,4)	(7,3)
	7	(7,3)	(6,4)	8	(7,3)	(6,4)
Public chat	9	(6,4)	(7,3)	10	(6,4)	(7,3)
	11	(7,3)	(6,4)	12	(7,3)	(6,4)
	13	(6,4)	(7,3)	14	(6,4)	(7,3)
	15	(7,3)	(6,4)	16	(7,3)	(6,4)
No chat	17	(6,4)	(7,3)	18	(6,4)	(7,3)
	19	(7,3)	(6,4)	20	(7,3)	(6,4)

Notes. Each row represents two sessions. Table cells contain the sizes of (Majority, Minority) for each treatment. For each communication regime and voting cost, each session combined two size treatments and had 20 rounds total, with two independent electorates in each round.

We did not inform subjects about the number of matches in each part. Instructions for part 2 were delivered after part 1 concluded. Two rounds from each part were randomly selected and the subjects paid, so the payoff of each subject was the sum of payoffs in four rounds plus the show-up fee of $7. Overall, the 20-session, $2 \times 2 \times 3$ design used 400 subjects, which generated a dataset with a total of 800 elections. The average payoff per subject was $28.99. Sessions with communication lasted approximately 1.5 hours, and sessions without communication took a bit less than one hour.[14]

Table 2 summarises our design and experimental parameters.

4. Results

For each treatment, Figure 2 presents the averages of turnout rates in each party and the total turnout rate.[15] The corresponding numerical values are reported in Table A1 in online Appendix A. With our $2 \times 2 \times 3$ design and 20 sessions, the total number of elections was 40 in each NC treatment and 80 in each GC and PC treatment. To account for possible correlation across rounds and across ten-person groups (as group composition changed after every round), we treated each group over 10 rounds as a panel, and computed panel-corrected standard errors with a correction for first-order autocorrelation within each panel.[16] Figure 2 shows a number of differences across treatments, which we discuss and test below.

A quick comparison with the theoretic predictions for max-turnout equilibria in Table 1 shows that Nash equilibrium is not very consistent with the behaviour observed

[14] All sessions were conducted at the UC-Irvine Experimental Social Science Laboratory (ESSL). The computer software was developed using the Multistage framework (http://multistage.ssel.caltech.edu).

[15] For expositional clarity, for many of our results, we report additional supporting figures and estimation details (e.g. standard errors and p-values) in online Appendix A.

[16] We also ran the standard two-sample t-test for comparison of means across treatments, which assumes independent observations in each sample, and found very similar results. Clustering by subject also produced similar outcomes. The findings we report in Figure 2 and Table A1 are more conservative.
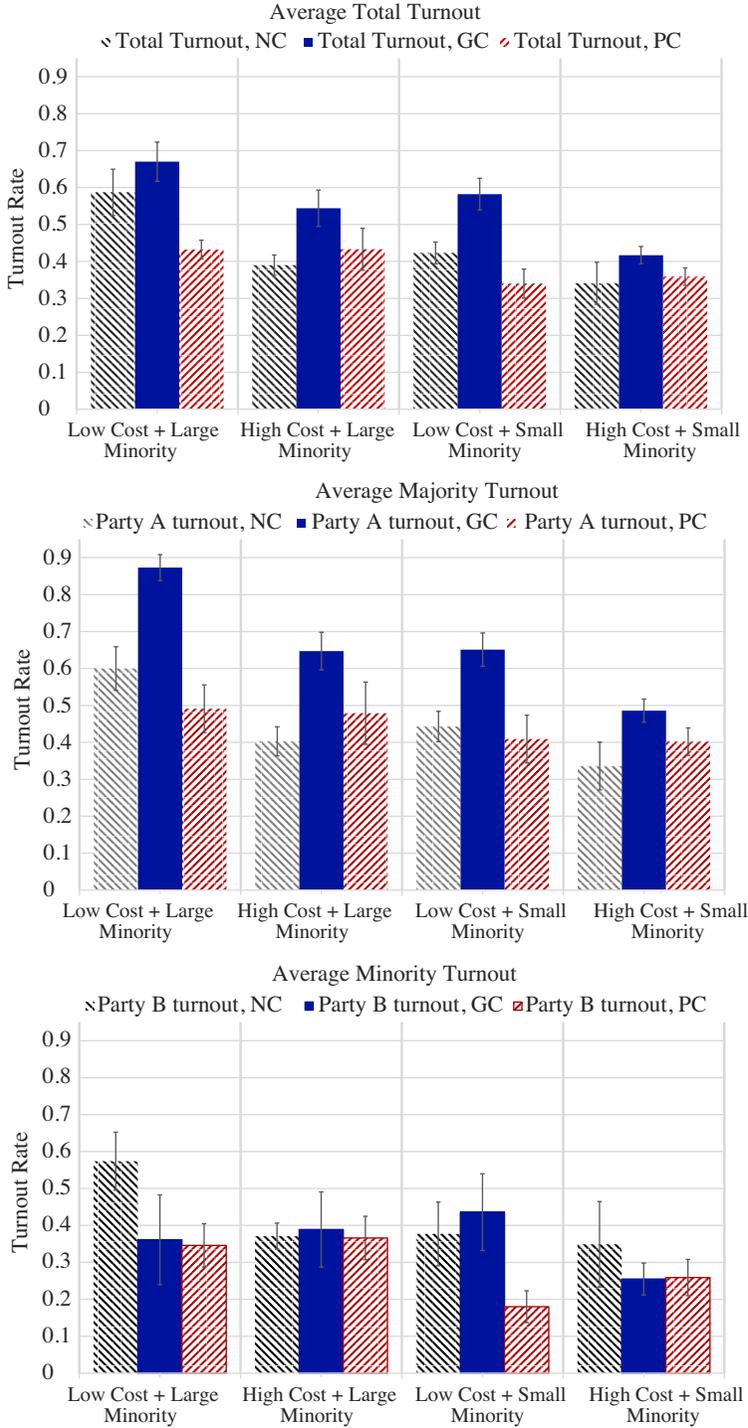
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Average Total Turnout

Average Majority Turnout

Average Minority Turnout

Fig. 2. *Average Turnout Rates*

Note. Colour figure can be viewed at https://academic.oup.com/ej.

in our experiment: average total turnouts rates in the data are much higher (with one exception) than in the maximal turnout Nash equilibria predictions of Table 1, already in the NC treatment, and even more so in the GC treatment. Similar to the stylised facts from real-world elections and many past experimental findings, voters in the laboratory tend to over-vote compared to the Nash equilibrium.

In contrast, a casual inspection of the turnout rates suggests that the data might be consistent with correlated and subcorrelated equilibrium predictions, although to establish this more rigorously requires a deeper analysis, which we present below in subsection 4.5.

Total turnout rates in Figure 2 are somewhat lower than the max-turnout correlated and subcorrelated equilibrium predictions in Table 1, but they seem to satisfy the constraint of the turnout upper bound. Thus, it might be possible to associate correlated and subcorrelated equilibria with expected turnout that would match the data. In order to check this, we develop and apply a formal direct test for consistency with correlated and subcorrelated equilibria in subsection 4.5.2.

Figures A2–A3 in online Appendix A provide a more-detailed presentation of voting patterns in the majority and minority parties. There, we also estimate individual voting probabilities for each subject, and group them by treatment and session to assess between-session variability (see Figures A4 and A5 in online Appendix A).

The remainder of this Section is organised as follows. In subsections 4.1–4.3, we statistically test the treatment effects of changes in communication protocol, voting cost and relative party sizes. These behavioural effects are tested for using group-level decisions and do not rely on specific assumptions about equilibrium behaviour. In subsection 4.4, we check robustness of test results to multiple hypothesis and learning using regression analyses. In subsection 4.5, we look at voting profile frequencies and check whether these patterns are consistent with equilibrium behaviour. In subsection 4.6, we focus on communication treatments and report the analysis of the chat logs.

4.1. *Effects of Communication on Turnout*

We start our analysis by looking at the main effect of interest: how communication affects turnout.

RESULT 1. (*Total Turnout*). *Group communication increases total turnout. Public communication decreases turnout under low cost, and has no effect under high cost.*

Support. To test for the effect of communication on total (and party) turnout, we compared the average turnout rates under two different communication modes, while keeping party sizes and voting cost fixed.[17]

From Table 3, we see that, for each treatment, GC increases total turnout, compared to NC. By contrast, the effect of PC is quite mixed. With high cost, PC has no significant

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[17] We report two-sided p-values in Table A3 in online Appendix A.

Table 3

Effects of Communication on Turnout and Victory Margin

n_A	n_B	c	$\Delta \hat{T}_A$	$\Delta \hat{T}_B$	$\Delta \hat{T}$	$\Delta \hat{T}_A - \Delta \hat{T}_B$	ΔMargin
Group communication minus no communication							
6	4	0.1	0.274***	−0.214***	0.083**	0.490***	0.447***
–	–	0.3	0.244***	0.018	0.154***	0.227***	0.264***
7	3	0.1	0.208***	0.060	0.160***	0.150**	0.118
–	–	0.3	0.150***	−0.094	0.076**	0.244***	0.331***
Public communication minus no communication							
6	4	0.1	−0.108**	−0.229***	−0.155***	0.121*	0.124*
–	–	0.3	0.076	−0.004	0.044	0.085*	0.172***
7	3	0.1	−0.034	−0.196***	−0.082***	0.162**	0.143
–	–	0.3	0.066*	−0.091	0.018	0.153**	0.257**

Note. Significance codes: *** < 0.01, ** < 0.05, * < 0.1.

effect on total turnout. On the other hand, PC decreases turnout significantly with low cost for both size treatments.

RESULT 2. (*Party Turnout*). *Communication affects party turnout differently for the majority and minority parties: in all cases, communication increases (decreases) turnout more (less) for the majority party than for the minority party. Thus, communication always increases the expected margin of victory for the majority party. With group communication, it uniformly increases majority turnout and has either no effect or a negative effect on minority turnout. With public communication and low cost, it decreases turnout by minority, with a smaller in magnitude, or no effect on majority; with high cost, there are no significant effects.*

Support. Looking at the party turnout rates in Table 3, we see that GC increases majority turnout for each treatment, compared with NC. PC increases majority party turnout for large majority size and high cost, but decreases majority turnout under low cost (the decrease is not significant for the large majority treatment).

The effect of communication on minority turnout is less pronounced. GC decreases minority turnout, compared to NC for the large minority and low cost. PC decreases minority turnout, compared to NC for low cost, decreases for high cost are not significant.

The next-to-last column of Table 3 shows the difference between the marginal effect of communication on majority turnout compared to its effect on minority turnout. In all cases, $\Delta \hat{T}_A - \Delta \hat{T}_B$ is positive and statistically significant. Because $n_A > n_B$, this implies immediately that communication increases the expected margin of victory for the majority party.[18] The increase is significant in all treatments except for the low cost, small minority. See the last column of Table 3.

Next, we look at the effects of communication on several electoral characteristics: probability of ties, pivotal events and upsets.

[18] The expected margin of victory is defined in (14).

Table 4

Effects of Communication on Electoral Characteristics

n_A	n_B	c	ΔTie	ΔPivot	ΔUpset
Group communication minus no communication					
6	4	0.1	-0.256***	-0.312***	-0.231***
–	–	0.3	-0.133	-0.214***	-0.045
7	3	0.1	-0.082	-0.079	-0.064
–	–	0.3	-0.139	-0.199***	-0.127**
Public communication minus no communication					
6	4	0.1	-0.072	0.022	-0.047
–	–	0.3	-0.080	-0.126*	0.065
7	3	0.1	-0.004	-0.012	-0.033
–	–	0.3	-0.077	-0.083	-0.094

Note. Significance codes: *** < 0.01, ** < 0.05, * < 0.1.

RESULT 3. (*Pivotal Events and Upsets*). *Communication nearly uniformly decreases probabilities of ties and pivotal events, and significantly so for pivotal events under group communication (all except for low cost and small minority), as well as one case of public communication with high cost and large minority. Communication nearly uniformly decreases the probabilities of upsets, with significant effects in half of the group communication treatments.*

Support. We report the corresponding results in Table 4.

From Table 4, we find that communication nearly always decreases probabilities of ties, pivotal events and upsets. Out of 24 comparisons, 22 have a negative sign. The effect is generally stronger for GC, and in all 12 GC *versus* NC comparisons, the effect is negative. However, these differences are significant in less than half the cases. The reason that these differences are generally negative follows almost directly from the earlier observation that communication (either GC or PC) always increases majority turnout by more than it increases minority turnout, leading to wider margins of victory for the majority and fewer close elections.

4.2. *Effects of Changing the Voting Cost*

Intuitively, increasing the voting cost should lead to a lower expected turnout. However, the equilibrium effect is ambiguous for a few reasons. First, even without communication, there are symmetric equilibria in which turnout is increasing in the cost;[19] and communication expands the set of equilibria relative to Nash, allowing for a wider range of expected turnout relative to the no-communication equilibrium. Second, communication allows voters to coordinate their actions, so it is possible that with communication, they might coordinate on a higher turnout equilibrium with high voting costs than with low voting costs.

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[19] This may sound counter-intuitive. However, as Palfrey and Rosenthal (1983, p. 42) note, for voters to be indifferent between voting and abstaining in a mixed Nash equilibrium, voting cost must equal their (endogenous) pivotal probability. In the high turnout symmetric equilibrium (with equal-sized parties), as the cost increases, so does their pivotal probability and, correspondingly, total turnout. See also a related result in Nöldeke and Peña (2016).

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RESULT 4. (*Cost Effect*). *Increasing the voting cost reduces the total turnout for each size and communication treatment, except public. In two out of these four treatments, these effects are driven by uniform changes in both parties' turnout rates; in the remaining two, they are driven by changes in one party's turnout only. Increasing the voting cost nearly uniformly increases the probability of pivotal events, with significant effects under group communication and large minority, and under no communication and small minority.*

Support. We first look at the effect of increasing the voting cost on turnout (Table 5), and then report the effects on the electoral characteristics (Table 6).

From Table 5, we see that reducing the voting cost increases total turnout for each size and communication treatment, except for PC. Breaking down the total turnout by parties, we see that these changes usually produce similar effects on party turnouts, except for GC with large minority, and NC with small minority, where the majority is affected more, and PC with small minority, where the minority is affected more.

Table 6 presents the corresponding effects of the cost change on the electoral characteristics considered earlier: the probability of ties, pivotal events and upsets.

From Table 6, we see that reducing the voting cost does not significantly affect the probability of ties. Reducing the cost decreases the probability of pivotal events under GC with large minority and under NC with small minority. The probability of upsets is nearly uniformly increasing in the cost (except for NC and large minority), but the changes are not significant.

4.3. *Effects of Changing the Relative Party Sizes*

We now turn to the effects of changing the party sizes while keeping the electorate size fixed. Intuitively, when the minority party is closer to 50%, a competition effect should lead to higher turnout in both parties. That is, the competition effect hypothesis is that turnout in each party is decreasing in $n_A - n_B$. Thus, increasing the minority party size from three to four at the expense of the majority party should increase turnout in each party. However, theoretically, this is not always the case with the highest turnout equilibrium: a more competitive election, *ex ante*, does not necessarily lead to higher equilibrium overall turnout. Furthermore, the effect of election competitiveness

Table 5

Effects of Cost on Turnout

			High cost minus low cost		
n_A	n_B	Communication mode	$\Delta \hat{T}_A$	$\Delta \hat{T}_B$	$\Delta \hat{T}$
6	4	NC	-0.196^{***}	-0.204^{***}	-0.197^{***}
–	–	GC	-0.226^{***}	0.028	-0.127^{***}
–	–	PC	-0.012	0.020	0.001
7	3	NC	-0.107^{***}	-0.027	-0.081^{**}
–	–	GC	-0.165^{***}	-0.181^{***}	-0.165^{***}
–	–	PC	-0.007	0.078^{**}	0.019

Note. Significance codes: *** < 0.01, ** < 0.05, * < 0.1.

Table 6

Effects of Cost on Electoral Characteristics

| | | | High cost minus low cost | | |
n_A	n_B	Communication mode	ΔTie	ΔPivotal	ΔUpset
6	4	NC	−0.067	0.127	−0.055
–	–	GC	0.056	0.225***	0.132
–	–	PC	−0.075	−0.022	0.057
7	3	NC	0.126	0.200**	0.108
–	–	GC	0.068	0.080	0.044
–	–	PC	0.053	0.129	0.047

Note. Significance codes: *** < 0.01, ** < 0.05, * < 0.1.

can be different for the majority and minority parties. Table 1 shows that in the high turnout, quasi-symmetric Nash equilibrium, the majority party turnout is higher in more-competitive elections, but minority turnout is actually depressed, and the theoretical effect of competitiveness on overall turnout can go either way; for our experimental parameters, the effect of competitiveness on overall turnout is positive if cost is low, but negative if cost is high. In both correlated and subcorrelated highest turnout equilibria, the effect of competitiveness on overall turnout and on minority turnout is positive, as intuitively expected. However, for the majority party, there is an interaction between cost and competitiveness. With high cost, the effect of competitiveness on T_A is positive, as expected, but with low cost, it goes the other way.

In contrast to the rather ambiguous theoretical implications about the competition effect, the data from the experiment speak quite clearly. In nearly all comparisons, there is a significant competition effect.

RESULT 5. (*Competition Effect*). *Increasing competitiveness increases total turnout, majority party turnout and minority party turnout.*

Support. The effects on turnout are reported in Table 7. The competition effect on total turnout is positive and significant in all cases but one in which it is not significant. The competition effect on majority party turnout is positive in all cases and significant in five out of six cases. The competition effect on minority party turnout is positive and significant in four out of six cases and is insignificant in the remaining two. Overall, the effects are not particularly consistent with the high-turnout equilibrium effects of competitiveness in Table 1, as the theoretical sign of the competition effect depends on the cost of voting, and can go in different directions for different parties. With a high voting cost, six out of nine differences are significant and have the same sign as the theoretical effect in Table 1. The remaining three differences are not significant. However, with a low voting cost, half of the differences are significant with the opposite sign.

While we observe strong competition effects on turnout, there are few significant effects on the probability of ties, pivotal events and upsets.[20]

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[20] See Table A8 in online Appendix A.

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Table 7

Effects of Changing the Relative Party Size on Turnout

c	Communication mode	$\Delta\hat{T}_A$	$\Delta\hat{T}_B$	$\Delta\hat{T}$
		Minority size 4 minus minority size 3		
0.1	NC	0.156***	0.198***	0.165***
–	GC	0.222***	−0.076	0.088**
–	PC	0.082*	0.165***	0.092***
0.3	NC	0.067*	0.021	0.049
–	GC	0.161***	0.134**	0.126***
–	PC	0.076	0.108***	0.074**

Note. Significance codes: *** < 0.01, ** < 0.05, * < 0.1.

4.4. *Robustness of Treatment Effects*

In this subsection, we discuss two potential concerns about the aggregate treatment effects reported in subsections 4.1–4.3. First, pairwise comparisons may suffer from multiple hypothesis testing problems and require type I error correction. Second, aggregate results may mask subject learning over time.

In order to partially alleviate both of these concerns, we ran several regression analyses for each party and total turnout, as well as the margin of majority victory. Table 8 reports the results for logit (columns (1)–(3)) and Tobit (column (4)) specifications. The dependent variable is the binary decision to vote (except for column (4), in which it is the normalised margin).[21] The regressors are treatment dummies and their interactions.[22] The standard errors are clustered at the group-round level. To account for potential learning over time, we included an early round dummy variable taking value of 1 for rounds 1–5 and value of 0 for rounds 6–10 of each treatment.

The regression analysis results are consistent across treatments. First, we found no evidence of learning: none of the early rounds dummies was significant on their own or as part of any interaction terms.[23]

Second, as Table 8 shows, the main results in subsections 4.1–4.3 follow through: Group communication increases total turnout. Public communication decreases total turnout with low cost as the interaction terms Comm × Cost indicate. Increasing voting cost reduces everyone's turnout. Increasing minority size (i.e. competitiveness) increases turnout but the effect is only significant in interactions with cost. Group communication increases the majority victory margin, although there is a negative effect when interacted with size and voting cost.

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[21] The regression in column (4) uses a Tobit specification with bounds −1 and 1.

[22] We also carried out regressions with vote shares (i.e. turnout rates) as dependent variables, for Tobit and OLS specifications. The results are qualitatively similar.

[23] To avoid clutter, the regression estimates of the early rounds dummies and their interactions are omitted in Table 8.

Table 8

Regressing Party and Total Turnout on Treatment Dummies

		T_A	T_B	T	Margin
Const		-0.475^{**}	-0.457^{***}	-0.468^{***}	0.104
		(0.229)	(0.174)	(0.150)	(0.139)
Comm	GC	1.004^{***}	0.052	0.619^{***}	0.400^{**}
		(0.311)	(0.311)	(0.237)	(0.168)
	PC	0.442	0.000	0.268	0.272
		(0.286)	(0.295)	(0.202)	(0.175)
Size	$n_A = 7$	-0.175	-0.161	-0.172	0.290
		(0.322)	(0.332)	(0.250)	(0.218)
Comm $\times$ Size	GC, $n_A = 7$	-0.425	-0.403	-0.300	-0.019
		(0.408)	(0.504)	(0.334)	(0.254)
	PC, $n_A = 7$	-0.287	-0.228	-0.224	-0.052
		(0.400)	(0.486)	(0.320)	(0.266)
Cost	$c = 0.1$	0.916^{***}	0.863^{***}	0.895^{***}	0.102
		(0.327)	(0.312)	(0.216)	(0.175)
Comm $\times$ Cost	GC, $c = 0.1$	0.323	-1.188^{**}	-0.458	0.253
		(0.428)	(0.510)	(0.311)	(0.222)
	PC, $c = 0.1$	-0.766^{*}	-1.108^{***}	-0.895^{***}	-0.075
		(0.412)	(0.433)	(0.285)	(0.229)
Size $\times$ Cost	$n_A = 7, c = 0.1$	-0.553	-0.791	-0.617^{*}	0.078
		(0.423)	(0.499)	(0.320)	(0.267)
Comm $\times$ Size $\times$ Cost	GC, $n_A = 7, c = 0.1$	-0.134	2.286^{***}	0.900^{**}	-0.603^{*}
		(0.537)	(0.757)	(0.427)	(0.328)
	PC, $n_A = 7, c = 0.1$	0.341	0.389	0.415	0.092
		(0.535)	(0.680)	(0.416)	(0.339)

Notes. Significance codes: *** < 0.01, ** < 0.05, * < 0.1. Standard errors (in parentheses) are clustered at the group-round level, $N = 800$. Comm refers to communication mode. Size refers to majority size. In column (2), the controls are as follows. GC (group communication) and PC (public communication) are relative to NC (no communication). $n_A = 7$ is relative to $n_A = 6$. $c = 0.1$ is relative to $c = 0.3$. All specifications include a dummy for early rounds as well as all its interactions.

4.5. *Correlated Equilibrium Analysis and Tests*

In this subsection, we investigate whether adding communication results in a 'higher' correlation in voters' choices, and whether the data are consistent with correlated and subcorrelated equilibria. We start by making additional assumptions necessary for the tests and formulating the test hypotheses.

Assumptions and Hypotheses. For the analysis of correlation in the data, we need to apply Assumption 1, which reduces the number of possible profiles to a total of $(n_A + 1)(n_B + 1)$ different profiles – i.e. 32 and 35 profiles in the small minority (7,3) and large minority (6,4) treatments, respectively, for which frequencies can be estimated from the data. Furthermore, this assumption is also plausible to hold in our data, since player IDs within each party are randomly reassigned every round. In addition to Assumption 1, we need to assume that the joint probability distribution is fixed throughout the game to ensure consistency of the frequency estimates.

ASSUMPTION 2. (*Fixed distribution*). *The realised voting outcomes are drawn every round from the same joint probability distribution (not necessarily an equilibrium one).*

Next, we formalise and test the following three hypotheses:

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HYPOTHESIS 1. (*Independent Voting Decisions*). *Each voter votes independently with the same probability conditional on her party.*

HYPOTHESIS 2. (*Quasi-symmetric Nash*). *With NC, individual voting probabilities of the majority and minority party members, q_A^* and q_B^*, respectively, are determined by a quasi-symmetric Nash equilibrium.*

HYPOTHESIS 3. (*Correlated and Subcorrelated Equilibria*).

  (*i*) *With PC, the vote distribution is consistent with a correlated equilibrium;*
  (*ii*) *with GC, the distribution is consistent with a subcorrelated equilibrium.*

Hypotheses 1–3 inform us about important properties of voting behaviour with and without communication. If Hypothesis 1 holds, voting strategies can be described by two probabilities, q_A and q_B, for voters in the majority and minority party, respectively. Notice that Hypothesis 1 simultaneously requires independence and equal voting probabilities across voters within the same party, so, in principle, it can be rejected due to a violation of either property. But since Assumption 1 implies symmetry among all players in a party, we focus on testing for independence only. Thus, if we find that Hypothesis 1 does not hold, we interpret this as evidence for correlated voting. So, if Hypothesis 1 holds with no communication but is rejected with communication, this implies that communication introduces correlation. Moreover, this would immediately imply that the voting data with communication are not consistent with Nash equilibrium play.

If Hypothesis 2 holds, the two voting probabilities under NC are pinned down by the equilibrium conditions on q_A and q_B in (3) and (4). If Hypothesis 3 holds, then our simple communication protocols can effectively imitate a complex correlating device required for correlated and subcorrelated equilibrium implementation (in some correlated equilibria, private communication via some form of mediated communication would be required). If Hypothesis 3 is rejected, this could be due to voters not playing a group-symmetric correlated/subcorrelated equilibrium (e.g. because of being boundedly rational or having social preferences) or, perhaps, because mediated communication protocols are needed to implement the equilibrium correlating device.

4.5.1 *Correlation in voting decisions*
In this subsection, we investigate Hypothesis 1 and 2. The findings are summarised by:

RESULT 6. (*Independence and Correlation*). *Without communication, voters' turnout decisions are independent. Quasi-symmetric Nash is rejected under the high voting cost but not under the low voting cost and large minority. Introducing communication results in correlated turnout decisions in seven out of eight treatments, with no support for Nash equilibrium play.*

Support. First, we check Hypothesis 1. We employ two different tests to compare the probability distribution of joint voting profiles estimated from the data with the induced distribution under the null: Likelihood Ratio and Epps–Singleton, the latter being a more powerful non-parametric alternative to the Kolmogorov–Smirnov test for comparing discrete distributions (see online Appendix A.1 for test details).

Table 9

Test for Symmetric Independent Voting: Estimated versus Induced Distributions

Communication	n_A	n_B	c	ES test		LR test	
				W_2	p-val	LR	$\chi^2_{0.05}$
NC	6	4	0.1	1.173	0.883	35.780	46.194 (32)
–	–	–	0.3	0.962	0.916	35.631	–
GC	–	–	0.1	5.381	0.250	215.444***	–
–	–	–	0.3	19.339***	0.001	170.422***	–
PC	–	–	0.1	12.715**	0.013	66.029***	–
–	–	–	0.3	11.830**	0.019	112.384***	–
NC	7	3	0.1	4.636	0.327	16.694	42.557 (29)
–	–	–	0.3	3.979	0.409	30.330	–
GC	–	–	0.1	3.981	0.409	168.517***	–
–	–	–	0.3	12.202**	0.016	95.288***	–
PC	–	–	0.1	0.815	0.936	22.522	–
–	–	–	0.3	11.037**	0.026	73.897***	–

Notes. W_2 is the two-sample Epps–Singleton test statistic for discrete data, computed using a modified version of the external Stata routine, **escftest**. LR is the likelihood ratio, $\chi^2_{0.05}$ is the corresponding critical value with $(n_A + 1)(n_B + 1) - 3$ degrees of freedom (either 32 or 29). Significance codes: *** < 0.01, ** < 0.05, * < 0.1.

Table 9 shows that in all NC treatments, none of these tests rejects Hypothesis 1 (independent voting) at the 0.05 level. Hypothesis 1 is rejected by the likelihood ratio test for all communication treatments (except PC under low cost), as well as by the Epps–Singleton test under high voting cost for both PC and GC, and under low cost for PC. Thus, both the likelihood ratio and Epps–Singleton tests produce relatively consistent results. Since Epps–Singleton does not take into account the variance in the estimates $\hat{q}_A$ and $\hat{q}_B$, we are more confident in the likelihood ratio test when interpreting our results under communication.

In the NC treatments, we focus on testing Hypothesis 2 for the max turnout quasi-symmetric Nash equilibrium because the summary data statistics indicate very high turnout rates that are inconsistent with the low-turnout, quasi-symmetric Nash equilibrium.[24] The results of the Epps–Singleton test are reported in Table 10. We reject Hypothesis 2 under high cost (and, marginally, under low cost and small minority), but not under low cost and large minority. Thus, in the low-cost NC treatments, the data are roughly consistent with a max-turnout quasi-symmetric Nash equilibrium. For communication treatments, we find that voting decisions are correlated, so there is no consistency with Nash equilibrium.[25]

4.5.2 *Consistency with correlated and subcorrelated equilibria*
Having estimated the frequencies of all joint voting profiles, we can now test whether the realised vote distribution forms a correlated or a subcorrelated equilibrium.

The technical details of the tests for Hypothesis 3 are in online Appendix A.2. The main idea is to compare the estimated probabilities of the joint profiles $\hat{\mu}_{a,b}$ for each pair of vote counts (a, b) with the induced probabilities $\tilde{\mu}_{a,b}$ under the null of the respective

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[24] See Table A1 in online Appendix A.
[25] As an extra check, we tested and rejected Nash under all communication treatments.

Table 10

Test for Max-turnout Quasi-symmetric Nash under NC

			ES test	
n_A	n_B	c	W_2	p-val
6	4	0.1	2.752	0.600
–	–	0.3	48.595***	0.000
7	3	0.1	7.830*	0.098
–	–	0.3	26.193***	0.000

Notes. W_2 is the two-sample Epps–Singleton test statistic for discrete data, computed using a modified version of the external Stata routine, **escftest**. The null hypothesis is that the equilibrium distribution and the estimated distribution are the same. Significance codes: *** < 0.01, ** < 0.05, * < 0.1.

hypothesis. We compare the two distributions by means of a two-sample Epps–Singleton test.

RESULT 7. (*Correlated Equilibrium*). *Correlated and subcorrelated equilibria are both rejected for all public communication treatments and most group communication treatments. We do not reject correlated equilibrium under group communication and low cost. We also do not reject subcorrelated equilibrium under group communication, low cost and small minority.*

Support. Table 11 presents the results of our test for constraint violations for all of our treatments. Inconsistency with equilibrium (indicated by a test rejection) is generally due to the observation of too low a frequency of pivotal events, conditional on voting.[26]

We find, however, that under the low cost and GC, we cannot reject the null of aggregate voting behaviour being consistent with a correlated equilibrium (and marginally reject it for the large minority case). By contrast, we soundly reject the correlated equilibrium hypothesis in the remaining treatments.[27]

Table 11

Test for Consistency with Correlated Equilibrium

Communication	n_A	n_B	c	IU stat
GC	6	4	0.1	5.487*
–	–	–	0.3	67.698***
PC	–	–	0.1	12.893***
–	–	–	0.3	38.335***
GC	7	3	0.1	1.364
–	–	–	0.3	91.712***
PC	–	–	0.1	15.938***
–	–	–	0.3	44.282***

Notes. IU test statistic is defined in (A.8) in online Appendix A.2. Significance codes: *** < 0.01, ** < 0.05, * < 0.1.

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[26] See Tables A9–A12 in online Appendix A. The results from Table 11 should be interpreted with caution, because they are based on a relatively small number of observations, and because there are many possible profiles, so the data are rather sparse.

[27] Strictly speaking, this is a joint hypothesis of a correlated equilibrium and Assumptions 1–2.

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Table 12

Test for Consistency with Subcorrelated Equilibrium

Communication	n_A	n_B	c	IU stat
GC	6	4	0.1	16.429***
–	–	–	0.3	213.204***
PC	–	–	0.1	17.462***
–	–	–	0.3	95.414***
GC	7	3	0.1	4.759
–	–	–	0.3	124.498***
PC	–	–	0.1	30.390***
–	–	–	0.3	64.876***

Notes. IU test statistic is defined in (A.8) in Appendix A.2. Significance codes: *** < 0.01, ** < 0.05, * < 0.1.

Table 12 presents the results of our test for a subcorrelated equilibrium in the communication treatments.[28] The estimated group frequencies and equilibrium constraints are in Tables A11–A12 in online Appendix A.2.

We see from Table 12 that the test results for subcorrelated equilibrium are broadly in line with the results for correlated equilibrium, and that GC, low cost and small minority remains the only consistent treatment.

4.6. *Analysis of Chat Data in Communication Treatments*

In this subsection, we take a deeper look at the actual communication between subjects. Our main goals here are to try to understand how PC differs from GC and how the number of messages in different categories is related to turnout.

We recorded the messages that subjects exchanged during each pre-play communication stage and employed an independent research assistant to classify and code the messages according to 10 general categories, listed in Table 13.

We begin our analysis by looking at the message frequency distributions pooled across cost and group size treatments.

RESULT 8. (*Message Types*). *Public and group communication induce similar message frequencies overall, but public communication treatments have more strategy suggestions and fewer agreement and own plan messages than group communication treatments. About* 31% *of all messages are irrelevant in both communication treatments.*

Support. We compute message frequencies for each category listed in Table 13 and report them in the last two columns of that table. We observe a large fraction of irrelevant messages (code 0: about 31% of the total of about 13,109 (about 14,015) messages under GC (PC)). Other high-frequency categories of messages include strategy suggestions (code 6: about 22% of the total under GC and about 35% under PC); and discussion about the rules of the game (code 3: about 23% under GC and about 19% under PC.) The next two largest categories are messages expressing agreement (code 2: about 7% under GC and about 4% under PC) and messages informative about the history

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[28] Because the set of subcorrelated equilibria is contained in the set of correlated equilibria, rejection of correlated equilibrium implies rejection of subcorrelated equilibrium (and Nash equilibrium).

Table 13

Message Categories and Observed Aggregate Frequencies

Code	Description	Examples	GC, %	PC, %
0	Irrelevant	'hello'	30.81	31.30
1	Disagreement	'no!'	1.12	1.56
2	Agreement to a proposed joint strategy	'alright'	7.43	3.71
3	General discussion about rules	'you can only get 135 in type A'	23.22	19.26
4	Informative statement about history	'one A chose Y last time'	7.19	5.16
5	Question to others: what are we going to do?	'so X or Y?'	2.19	1.68
6	Strategy suggestion about others'/own/group decision	'if you're 1–4 pick x'	21.92	34.51
7	Own plan: will choose X	'I'll do X'	3.80	1.38
8	Own plan: will choose Y	'I'll do Y'	2.04	1.21
9	Ambiguous	'not sure'	0.27	0.23
		Total number of messages	13,109	14,015

of play (code 4: about 7% under GC and about 5% under PC). A smaller fraction of messages relate to questions to others and own plans (codes 5, 7 and 8, respectively.) The remaining categories – disagreement and ambiguous messages – comprise, on average, less than 1.7% of the total messages.[29]

To assess how the number of messages in different categories affects turnout rates, we estimate a simple linear relationship, regressing for each communication treatment the normalised total turnout[30] on the total number of messages in each code category.

RESULT 9. (*Message Effects*). *Irrelevant messages have no effect on the normalised turnout rate, despite their large share. Agreement messages increase normalised turnout (significantly with group communication); and disagreement messages decrease normalised turnout (significantly with public communication). Total turnout increases in the number of messages stating intent to vote and decreases in the number of messages stating intent to abstain. Since intent messages are mostly truthful, this effect is driven largely by voters' own turnout rather than their influence on others.*

Support. Table 14 reports estimates from an ordered probit model regressing the normalised total turnout on the number of messages in each of the categories (with standard errors and p-values reported in Table A15 in online Appendix A). We also estimate the ordinary least squares model and find very similar results.

While the intent messages (the last two columns of Table 14) show significant effects, it could well be the case that an increase (decrease) in total turnout is simply due to

[29] See Tables A13–A14 in online Appendix A for a breakdown of message frequencies by treatment and round. Those tables suggest that the patterns are not a by-product of pooling across rounds or treatments. One minor exception is that we observe a somewhat increasing proportion of irrelevant messages over rounds, especially under PC.

[30] Normalised total turnout makes data from cost and size treatments suitable for pooling together by taking into account deviations of individual observations from the treatment-specific averages. It is defined for each group-round election i in treatment $j \in$ {High cost, Low cost} × {Large minority, Small minority} × {Public, Group} as $t_{ij} = (T_{ij} - \bar{T}_j)/N_j$, where T_{ij} is the total number of votes; $\bar{T}_j$ is the average number of votes (mean turnout rate); and N_j is the number of group-round observations.

Table 14

Effects of the Number of Messages on Normalised Total Turnout in Communication Treatments

Communication	Message category						
	(Irrelev.)	(Disagr.)	(Agr.)	(Hist.)	(Q&S)	(Vote)	(Abst.)
Group	0.008	0.028	0.085[***]	0.029	0.013[***]	0.140[***]	−0.130[***]
Public	0.003	−0.038[***]	0.025	−0.002	−0.001	0.333[***]	−0.276[***]

Notes. Table cells contain for each message code ordered probit estimates of the effects of the total number of messages per electorate in that category on the normalised total turnout. Significance codes: *** < 0.01, ** < 0.05, * < 0.1. For clarity of presentation, we combined messages with codes 0, 3 and 9 into the 'Irrelevant' category. We also combined messages with codes 5 and 6 into the 'Q&S' category. The remaining message categories are as described in Table 13.

voters being truthful about their plans. To see whether voters expressing the intent to vote or abstain actually carry out their promises, we compute a 'truth' rate, defined for each election (group-round observation) as the ratio of truthful messages (i.e. a voter says that she will vote and does vote, or she says that she will abstain and does abstain) to the total number of intent messages in that election (i.e. messages with 'vote' and 'abstain' codes). The average truth rate (pooled across majority and cost treatments) for GC is 0.869 (s.e. $= 0.014$, p $= 0.000$), and for PC, it is 0.812 (s.e. $= 0.022$, p $= 0.000$). Thus, voters stating their intent are mostly truthful.

Estimating the effect of intent messages on others' turnout is far from straightforward: in the same chat, there could be several voters expressing the intent to turn out, or some expressing the intent to turn out and others the intent to abstain, and excluding all those who state any intent would conflate the effects. Our crude estimates (available upon request) show some effect of the intent messages on turnout through influencing the turnout of others, but the bulk of the change is driven by voters' own turnout (or non-turnout in the case of abstention).

5. Concluding Remarks

This is the first laboratory study to examine how unrestricted and party-restricted pre-election communication among voters affects turnout, by creating correlation between voter turnout decisions. The experiment investigated how changes in communication structure affect both turnout and electoral outcomes under different conditions on the cost of voting and *ex ante* election competitiveness.

There are a number of central findings of the experiment. The most important finding is that communication unambiguously benefits the majority party by increasing its expected turnout margin. This finding is robust to all the different treatment variations in the experiment. This result is surprising in the sense that we are not aware of any existing theoretical model that would predict this systematic finding, including the Nash equilibrium model and our related analysis of correlated equilibrium of the turnout game.

Second, we develop and apply a test for the effect of communication on correlation. With no communication, we find strong evidence of independence, but only limited support for symmetric mixed Nash equilibrium. With communication, individual voting

decisions are correlated, but again find only limited support for correlated equilibrium, and no support for Nash equilibrium. Overall, the effects of communication on correlation, and hence on outcomes, are significant and comparable in magnitude to the effects of changing the main exogenous parameters of the model, which have traditionally been viewed as key driving variables that influence turnout – i.e. voting cost and the competitiveness of the election.

Third, we observe an interaction effect between the forms of communication and the voting cost in terms of how these two factors influence overall turnout in elections. In particular, party-restricted communication increases turnout for both cost levels. Unrestricted public communication decreases turnout with a low voting cost and has no effect on turnout with a high voting cost. This has potentially relevant policy implications, especially since get-out-the-vote campaigns are shifting towards social media – reaching new levels of political communication – and since changes in voting technology and election laws affect the cost of voting.

Fourth, for most treatments, we find evidence for both a cost effect (turnout decreases in the voting cost) and a competition effect (turnout increases in the relative size of the minority).[31]

We wish to underscore the importance of developing rigorous theoretical models to explicitly take communication possibilities into account. Correlated and Subcorrelated equilibria provide a useful framework for this. Testing for these equilibria in our data is the first attempt to identify the general principles behind communication-based coordination in competing groups, using the correlated equilibrium approach.

Finally, one wonders how the results from our laboratory-scale elections extend to larger electorates, and how our correlated and subcorrelated equilibrium approach could be applied to model communication with many voters. These two questions are not independent. For example, practical limitations preclude efficient unmediated communication among all the members of a large electorate. In typical elections, communication to and between voters is partly coordinated and mediated by party leaders and activists, and the explosion of diverse social media networks induces unmediated communication to take place within many smaller clusters of users. Our approach is compatible with both of these features. In particular, mediated communication by leaders can make it even easier rather than harder to coordinate voters by inducing correlation in their turnout decision, and the existence of smaller clusters of groups who engage in unmediated communication via social media is consistent with our theoretical approach of modelling group communication using subcorrelated equilibrium, only with a finer partition of the set of voters. In a broader sense, this suggests that our findings about the turnout effects of group communication in the laboratory might have useful insights for the larger aggregate levels.[32] The partial success of this framework, especially the surprising and robust finding about the differential effect of communication on majority and

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[31] In addition to the turnout-related results, we also looked at the effects on welfare, which, in this model, highlights the tradeoff between the probability the majority party wins, the voting cost, and the expected total turnout. Reducing the voting cost or the relative minority size increases total welfare in all treatments. Communication increases welfare under low voting cost, but decreases it under high voting cost, for partition (7,3). See Table A1 in online Appendix A. More detailed results are available from the authors upon request.

[32] In the field, there can also be additional factors at play, such as social pressure (DellaVigna *et al.*, 2017) or ethical voting considerations (Coate and Conlin, 2004; Feddersen and Sandroni, 2006). We do observe some evidence of social pressure in the chat logs, but do not find evidence of ethical voting behaviour.

minority parties, invites further study. While beyond the scope of the current article, a very interesting and challenging extension of this initial study would be to explore the effects of mediated and unmediated communication in much larger laboratory elections.

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Additional Supporting Information may be found in the online version of this article:

Appendix A. Additional Details.
Appendix B. Sample Instructions.
Data S1.

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