



# **Communication and Information in Games of Collective Decision: A Survey of Experimental Results**

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# Communication and Information in Games of Collective Decision: A Survey of Experimental Results<sup>1</sup>

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# 1 Introduction and overview

Voting games and other collective decision situations pose particular challenges for game theory. Often, there is a plethora of Nash equilibria, which creates coordination problems, making it difficult for decision makers to reach the best equilibrium outcomes, or even any equilibrium outcome at all. In addition, voters often differ in their motivations and preferences, which may include pro-social or anti-social elements, and this heterogeneity further clouds best response behavior. Even when there is repeated interaction, opportunities to learn about other voters' motivations and plans are limited since often only aggregate information is available. Last but not least, side payments are often unavailable as a tool to price decisions or to provide compensation to losers and long term contracting is generally impossible.

And yet, political behavior is not characterized in the real world by relentless chaos. Communication and other pre-play activities involving the acquisition and transmission of information across voters may to some extent be responsible for the degree of coordination commonly exhibited in collective decision environments. Laboratory experiments inspired by political situations seem uniquely qualified to throw light in the effects of pre-play activities on behavior and coordination in collective decision environments, since they allow the researcher a greater degree of control and observability of information acquisition and information flows among voters. Thus, experiments can lead to a better understanding of the mechanisms by which voters achieve some order and in the longer run may potentially help us in improving the design of institutions for collective choice.

In this survey, we consider selectively lab experiments on voting games including pre-play activities such as: (1) release of information about realized preferences of voters (for example, via pre-election polls), (2) publicly observable signals about voting intentions (for example, via straw votes in committees), (3) other forms of unrestricted private or public communication, (4) costly messages (for example, via campaigns, advertising, or costly entry), (5) sequential decisions, which allow voters to observe some other voters' decisions, and (6) information acquisition activities. Formally, (2) and (3) are forms of cheap talk, which in these games can alter the set of equilibria of the games and may also serve to coordinate on a particular equilibrium. (1), (4), (5) and (6), instead, are alterations in the game form in more direct ways that go beyond mere cheap talk. We focus the survey on six areas that have received much attention in the last few decades: (i) costly voting in elections with two alternatives; (ii) (other) collective action problems; (iii) elections with more than two alternatives; (iv) electoral competition and democratic accountability with imperfect information; (v) information aggregation in committees and juries; and (vi) legislative bargaining. Table 1 offers an overview of papers discussed in the survey, classified by pre-play activities and research area.

A main lesson from the work reviewed in this chapter is that strategic behavior is pervasive in voting games, as opposed to naive or "sincere" behavior. That is, voters do attempt to play best responses to other voters' strategies. While the qualitative features predicted by Nash equilibrium and its refinements are often consistent with the data reported from these experiments, support for precise quantitative predictions is generally weaker. The literature is suggestive of a role for mistakes, as in Quantal Response Equilibrium (QRE), and diffi-

	preference information	decision intentions	free form communication	costly messages, information acquisition	sequential decisions
costly voting	Klor and Winter (2007, 2014), Großer and Schram (2010), Agranov et al. (2017)	Agranov et al. (2017)	Bornstein (1992), Schram and Sommers (1996), Großer and Schram (2006), Pogorelskiy and Palfrey (2017)		
collective action	Palfrey and Rosenthal (1991b), Palfrey et al. (2017)	Agranov and Tergiman (2014), Baranski and Kagel (2015) Palfrey et al. (2017)	Orbell et al. (1988), Isaac and Walker (1988), Ostrom et al. (1991), Palfrey et al. (2017)	Isaac and Walker (1991)	
multicandidate elections	Tyszler and Schram (2011, 2013), Bouton et al. (2017)	Forsythe et al. (1993, 1996)	Kittel et al. (2014)	Reitz et al. (1998)	Morton and Williams (1999)
elections with imperfect information		McKelvey and Ordeshook (1985a), Plott (1991), Dasgupta and Williams (2002)		Lupia (1994), Houser and Strammann (2008), Houser et al. (2011, 2016)	
information aggregation in committees		Guarnaschelli et al. (2000)	Goeree and Yariv (2011)	Elbittar et al. (2016), Großer and Seebauer (2016), Bhattacharya et al. (2017)	Hung and Plott (2000), Battaglini et al. (2007), Ali et al. (2008)
legislative bargaining			Agranov and Tergiman (2014), Baranski and Kagel (2015), Agranov and Tergiman (2016), Baron et al. (2017)		

Table 1: Pre-play activities in games of collective decision

culties in handling Bayesian updating in the presence of incomplete information, sometimes modeled as judgement fallacies. Mistakes and biases are not altogether surprising in environments in which there is little feedback and (often) a small probability of an individual voter's behavior changing the social outcome. In those situations, for instance, voters' behavior in the lab may be guided not only by learning while playing the game, but also by analogy with other situations voters may have faced before, introducing unobserved heterogeneity. Pre-play activities such as pre-election polls and free communication can guide players in the direction best-response behavior by resolving some of the strategic uncertainty about intentions of other voters; in some cases, when there are multiple equilibria, by helping voters coordinate their behavior. As a consequence, it is often the case that game theoretic solution concepts help organize and understand the observed behavior better when communication is allowed. We refer to this as an *equilibrium effect* of pre-play activities.

Another main lesson from the work reviewed is that social motivations tend to have an impact on the behavior of players in voting games. In particular, the welfare of the group of reference induced by the experiment (which may not be the entire "society" participating in the experiment) seems to be an effective motivation in several cases. Pre-play activities often reinforce the importance of the group welfare, be it because they make salient the welfare of the group of reference for voters, or because they allow voters to coordinate their behavior or engage in implicit agreements. We refer to this as an *efficiency effect* of pre-play activities. As illustrated by some of the work revised below, the impact of pre-play communication on behavior is magnified when the forces of equilibrium and efficiency push in the same direction.

Voting is a fundamental institution to reach collective decisions, comparable to the role of voluntary exchange and market prices as fundamental institutions for the allocation of private goods. Just as in the case of markets, experimental research, in combination with game theory, has helped throw some light on very old questions regarding voting. The literature we review here illustrates the point that focusing exclusively on the formal rules for decision-making in isolation of the opportunities of voters to acquire information about the alternatives and to communicate and coordinate their behavior misses an essential ingredient of political institutions. Because of the ability to control and observe the acquisition and transmission of information among voters, lab experiments hold the promise of a better understanding of what makes voting work.

The literature surveyed is still evolving, and much remains to be done. Further experimental research may help us understand better, for instance: the endogenous formation of communication networks among voters and its impact on incentives for information acquisition, information transmission, voter coordination, and prosocial attitudes; the interaction between networks of communication between voters and "big players" such as opinion leaders and media; the impact of changes in the technology of communication on voting and other forms of political behavior such as demonstrations and protests; and the impact of information acquisition and communication on electoral accountability and the control of politicians by voters.

In the remainder of the chapter, we dedicate a section to each of the research areas identified above, corresponding to the rows of Table 1. We conclude by comparing the effects

of pre-play activities across the different environments considered as well as by identifying some open research questions.

## 2 Costly voting

The formal theoretical analysis of voting behavior starts in earnest with the work of Black (1958), Buchanan and Tullock (1962), Downs (1957), Tullock (1967) and Riker and Ordeshook (1968), and in particular with the observation that voting is costly, and that the decision to vote may be influenced by the expectations held by the voter regarding the probability of affecting the outcome of the election. Consider the following (complete information) game, adapted from Palfrey and Rosenthal (1983), who first analyzed costly voting in a full-fledged game model.  $N$  voters,  $i = 1, \dots, N$  must decide between two alternatives,  $A$  and  $B$ . Voters can either vote for  $A$ , vote for  $B$ , or abstain; the collective decision is made by *simple plurality*, that is, whichever alternative receives most votes is chosen, with ties broken by tossing a fair coin.  $N_A$  voters favor alternative  $A$  and the remainder  $N_B = N - N_A$  favor alternative  $B$ , with  $N_A \geq N_B > 0$ . The following matrix describe the payoffs accruing to each voter as a function of the outcome of the election and whether the voter casts a vote for her preferred alternative or abstains:

	vote	abstain
favorite alternative wins	1-c	1
favorite alternative loses	-c	0

where  $c \in (0, 1/2)$  is the cost of voting. The game has pure strategy Nash equilibria only under extreme circumstances, when  $N_A = N_B$ , but it has many mixed strategy equilibria. The mixed strategy equilibrium that has received most attention in the literature is the *quasi-symmetric equilibrium* in which all voters in favor of the same alternative follow the same strategy, i.e., randomize with the same probability between casting a vote for the preferred alternative and abstaining. While the quasi symmetric equilibrium is appealing, strategic uncertainty looms as a potential difficulty for equilibrium behavior. Note that the utilitarian socially optimal strategy profile is for a single voter to cast a vote in favor of  $A$  if  $N_A > N_B$ , and for no one to vote if  $N_A = N_B$ , but neither of these profiles is a Nash equilibrium, and equilibrium turnout rates always exceed this very small amount of turnout.

Palfrey and Rosenthal (1985) introduce private information about the cost for each voter in the costly voting game. The cost of voting for each supporter of alternative  $A$  is an independent draw from the commonly known distribution,  $F_A$ , and the cost of voting for each supporter of alternative  $B$  is an independent draw from the commonly known distribution,  $F_B$ , where  $F_A$  and  $F_B$  have continuous density functions and no mass points. A quasi-symmetric Bayesian equilibrium of this incomplete information game can be described by a pair of cut-off costs  $(\bar{c}_A, \bar{c}_B)$ , one for the supporters of each candidate, so that voters in favor of each candidate abstain if and only if their cost of voting exceeds the cutoff, and vote for their favorite otherwise. While it is still possible for multiple equilibria to exist, there are robust conditions under which the equilibrium will be unique.

Levine and Palfrey (2007) tests the equilibrium predictions of Palfrey and Rosenthal (1985) in a laboratory experiment; though they do not include communication or other pre-play activities, their work sets a useful benchmark for our later the discussion of the literature. The results of the experiment support the three key qualitative predictions of equilibrium: the *underdog effect*, whereby voters in the minority party vote with higher frequency than voters in the majority party, the *size effect* where turnout is decreasing in the number of voters, and the *competition effect*, where turnout is higher if the relative size of the minority party is closer to 50%.<sup>1</sup> They detect smaller than Bayesian equilibrium levels of turnout in small electorates, and larger than Bayesian equilibrium levels of turnout in large electorates (in particular, in their treatment with the largest electorate, 51 voters). These deviations from Bayesian equilibrium are consistent in direction with regular QRE, and they find that a simple logit specification of the error structure fits the data reasonably well quantitatively, McKelvey and Palfrey (1995), although somewhat underestimating the observed turnout levels in the largest electorates.<sup>2</sup>

The literature on pre-play stages in the costly voting game has two strands. The first strand introduces rounds of anonymous, free format, chat communication among voters in complete information situations in which  $N_A = N_B$ . The stated purpose of the design is to explore the role that group identification or “civic duty” may have in increasing turnout above Nash equilibrium levels, a possible explanation of the substantial participation rates observed in mass elections.<sup>3</sup> The underlying idea is that communication may either help to coordinate behavior in achieving larger turnout for each group, or even affect individual preferences, adding a civic duty component to the voters’ payoff of casting a vote. The second strand introduces pre-election polling in an incomplete information version of the Palfrey and Rosenthal (1985) model in which there may be uncertainty about the preferences of voters. The aim is to explore whether the availability of information about the preferences of voters via polls leads in the direction of the predictions of the quasi-symmetric equilibrium, with some interest in whether there is an underdog effect.

Bornstein (1992) reports an experiment that introduces a round of communication in a threshold public good provision game with intergroup conflict similar to the costly voting game with  $N_A = N_B = 3$ , and they report that intragroup communication increases participation, while intergroup communication depresses it. In all cases participation rates fall well short of the Nash equilibrium participation rate of 100%. Each competing group in the experiment has three members; communication was introduced as a five minute discussion, taped by an experimenter, before subjects decides individually whether to contribute toward

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<sup>1</sup>In the special case where the party sizes are 2 and 1, there is a *reverse* underdog effect in equilibrium, which was also observed in the experiment.

<sup>2</sup>An experiment reported in Herrera et al. (2014) extends the theoretical model of Palfrey and Rosenthal (1985) and the experimental design of Levine and Palfrey (2007) by comparing turnout under winner-take-all and proportional representation voting systems. Turnout is higher in winner-take-all systems if the competing parties are of nearly equal size, while the opposite is true in landslide elections. This confirms the comparative static predictions of Bayesian Nash equilibrium. Kartal (2015) reports the result of a similar experiment, but where the relative party sizes are a random variable. They obtain the first result, but not the second.

<sup>3</sup>This raises a design issue, since with  $N_A = N_B$ , there is a symmetric pure strategy Nash equilibrium with 100% turnout. It is hard to see how communication or group identity could increase turnout above that level!

their group defeating the other.<sup>4</sup>

Schram and Sonnemans (1996) investigate, in one of several other treatments, the effects on turnout of communication in two costly voting games, one similar to Palfrey and Rosenthal (1983), except with  $N_A = N_B = 6$ , and the other where the probability of winning is proportional to the votes for each group. Each competing group had six members; communication is introduced as a five minute discussion after twenty rounds, and before playing five additional rounds beyond round twenty.<sup>5</sup> Communication does initially exhibit an immediate and strong effect on turnout, increasing average turnout in round 21 compared to round 20 in each group from an average of 1.42 to 2 in each of the teams under proportional representation, and from 1.23 to 3.73 under simple majority. However, the effect seems to be temporary, fading in rounds 22-25 monotonically back down in the direction of the round 20 levels. Noteworthy, with respect to both the Schram and Sonnemans (simple majority) and Bornstein experiments is that the unique pure strategy Nash equilibrium is for all subjects to vote. Thus, in all treatments studied there is significant under-voting relative to the equilibrium, as observed also by Levine and Palfrey (2007) in small electorates, and the main effect of communication is to move behavior in the direction of Nash equilibrium.

Großer and Schram (2006) introduce *local* communication in the costly voting game. They implement elections with competing groups of six members, as in Schram and Sonnemans (1996), but split each group into three sender-receiver pairs of “neighbors.” Senders are allowed to vote early or late, while receivers can vote only late; each sender can report (truthfully or not) to their neighbor receiver whether or not he voted early. In the “strangers” treatment, group assignments are reshuffled at the beginning of each round. When neighbors know they are paired with members of the same group, senders signal their preference for joint participation by voting early, and receivers, in turn, reciprocate a reported early vote by their sender/neighbor by voting themselves at higher rates than after observing abstention. In contrast, when neighbors belong to different groups, receivers act as if (correctly, it turns out) senders’ messages are uninformative. As a result sender reports of early voting have no effect on their neighbors’ turnout. In the “partners” treatment, subjects are kept together in the same group all rounds; in this case neighborhood information exchange among members of the same group also raises turnout, though the mechanism does not seem to be reciprocity regarding senders.<sup>6</sup> In sum, intragroup local communication again leads in the direction of pure strategy Nash equilibrium.

Pogorelskiy and Palfrey (2017) examine the effect of communication on turnout in elections where voters have complete information but the two parties are of unequal size. This allows them to examine whether communication has a differential effect on the larger or smaller party and also avoids the difficulty of having a design where 100% turnout is the

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<sup>4</sup>See also Bornstein and Rapoport (1988) and Bornstein et al. (1992), which investigate the effect of pre play communication in competitive public goods games, which are also related to the games discussed in the collective action section of this survey.

<sup>5</sup>Groups were kept constant across the rounds. Subjects were really playing a repeated game, which is a confounding factor.

<sup>6</sup>In the partner environment, subjects are really playing a repeated game, so there is some theoretical disconnect in comparing outcomes to the Nash equilibrium in the one-shot.



unique pure strategy Nash equilibrium. Because the parties are of different sizes, there is no pure strategy equilibrium. The theoretical basis for the effect of communication in their experiment is developed in Pogorelskiy’s (2015) analysis of correlated equilibria in voter turnout games. That paper shows that the set of correlated equilibrium greatly expands the equilibrium strategy profiles compared with Nash equilibrium in such games, allowing the possibility for much higher equilibrium turnout rates with communication compared to no communication. Moreover, the set of correlated equilibria depends on whether the correlation can occur only within parties or both within and across parties, with the latter set generally containing the former set. The treatments in Pogorelskiy and Palfrey (2017) vary the voting cost, the size of the minority party, and the constraints on communication between voters. The main finding is that *communication consistently benefits the majority party* by increasing the turnout rate differential between the two parties. This finding is robust to both the size of the minority and the voting cost. The mechanism that produces this phenomenon remains an open question. In contrast to Schram and Sonnemans (1996) and Großer and Schram’s (2006) results, communication does not consistently increase voter turnout in either party. One reason for this might be that there does not exist a unique symmetric Nash equilibrium with one hundred percent turnout in both parties. Rather a pure strategy Nash equilibrium fails to exist, so the set of correlated equilibria that can be induced by communication in turnout games with different sized parties can exhibit both higher and lower turnout than the mixed Nash equilibrium of the game.

In the second strand, i.e., pre-play communication in the form of anonymous polls, Großer and Schram (2010) compare a situation in which voters are informed of the exact values of  $N_A$  and  $N_B$  (interpreted as a poll) with a situation in which they only have probabilistic information about  $N_A$  and  $N_B$ . In particular, they consider a setting with a total of twelve voters in which preferences are determined randomly in each round, with each group having at least three voters. They show that poll releases have a strong effect on voter turnout. Most strikingly, and at odds with the quasi-symmetric equilibrium, when voters are informed turnout increases in the level of disagreement (the expected value of  $|N_A - N_B|$ ) in what amounts to a reverse competition effect. Moreover, majority voters turn out at higher rates than the opposing minority voters after a poll. That is, there is a *bandwagon effect*. This behavior, which is similar to what Palfrey and Pogorelskiy (2017) observed with pre-play communication, is at odds with the underdog effect predicted by the quasi-symmetric equilibrium. The theoretical basis for the observed bandwagon effect in these environments is an open question. Klor and Winter (2007, 2014) perform a similar comparison in a setting with seven voters. They observe that voters in the majority turn out at significantly higher rates than subjects in the minority, but only in closely divided (4 – 3) electorates.

Agranov et al. (2017) report an experiment with polls, preference uncertainty, and costly voting, using nine-voter groups. The environment is a specialized version of the theoretical models of Goeree and Großer (2007) and Taylor and Yildirim (2010). Each voter is independently drawn with replacement to be either a member of party  $A$  or party  $B$ , with  $p$  being the probability of being assigned to party  $A$ . There are two equally-likely states of the world, which determines  $p$ . In state  $A$ ,  $p = 2/3$ . In state  $B$ ,  $p = 1/3$ . Voters do not know the state but their own assignment provides an informative private signal about the state. After observing

which party they are assigned to, they either vote for  $A$ , vote for  $B$ , or abstain.<sup>7</sup> Voting is costly. They compare three different pre-play information treatments. The first treatment is the baseline, and voters are given no information other than their own assignment. In the second treatment, the state is publicly announced prior to everyone's voting decision ("perfect polls"). In the third treatment, prior to the voting stage, there is cheap talk communication in the form of polls, which is equivalent to each voter simultaneously broadcasting a ternary message (" $\emptyset$ ", " $A$ ", or " $B$ ") to every other voter, with one interpretation being their vote intention, and in the case of announcing " $A$ " or " $B$ ", providing information to other voters about the state.<sup>8</sup> As was found in Großer and Schram (2010) and Klor and Winter (2007, 2014), they observe a bandwagon effect: voting propensity increases systematically with the poll's indication of their preferred alternative's advantage. This leads to more participation by the expected majority and generates more landslide elections. Again, the observed behavior is inconsistent with equilibrium, which poses interesting and unresolved theoretical questions.

Großer and Schram (2010), Klor and Winter (2007, 2014), Pogorelskiy and Palfrey (2017), and Agranov et al. (2017) consider environments where the cost of voting is homogeneous and common knowledge, as opposed to the private cost environment of Levine and Palfrey (2007). This introduces equilibrium multiplicity, and makes direct comparisons difficult.<sup>9</sup> In Agranov et al. (2017) and in Pogorelskiy and Palfrey (2017), equilibrium multiplicity is further compounded by the possibility of strategic behavior respectively in polls and in free-form communication. Taking cautiously the evidence on bandwagon effects, one might conjecture two possible sources for this behavior, one based on beliefs and the other based on preferences. Regarding beliefs, it may be that voters overestimate the probability of being decisive, as proposed by Klor and Winter (2014) and in line with the work of Esponda and Vespa (2014). The other possibility is that voters do like to vote for the winner, a *preference for conformity* as proposed by Callander (2008) and others. Yet another possibility is that voters have altruistic preferences, or preferences for efficient outcomes, as we mention in the introduction. In this line, Großer and Schram (2010) propose an explanation of the observed behavior based on group goals being seemingly internalized by voters when they believe to be in the majority group. Agranov et al. (2017) elicit voters' beliefs about the probability of being decisive that seem to be fairly accurate, and show that introducing in the costly voting model a type of voters who likes to vote for the winner is one plausible explanation for their data. Whether there is in fact a bandwagon effect when strategic uncertainty is not an issue, what is the likely origin of this behavior pattern, and whether bandwagon effects are more prevalent for larger electorates are still interesting and very much open questions.

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<sup>7</sup>Obviously voting for the party one does not belong to is a dominated action.

<sup>8</sup>This is a similar communication protocol to that in Guarnaschelli et al. (2000), which we review later in the survey, with the exception of the announcement abstention. However, Guarnaschelli et al. (2000) examine information aggregation in a pure common value environment, whereas Agranov et al. (2017) study a pure private values environment.

<sup>9</sup>In the heterogeneous private-known cost environment, equilibrium uniqueness obtains for the parameters that have been used in experiments.

### 3 Collective Action

Problems of collective action and free-riding behavior are present in many forms and studied by political scientists, economists, sociologists, and social psychologists under many different names, such as: the public goods problem; social dilemmas; and the tragedy of the commons. All basically share the common element of a conflict between group interests and the selfish individual interests of the group members. Unlike costly voting, collective action environments do not necessarily pitch one group against another, and potentially allow for a richer action space and a richer set of outcomes. Traditional applications include the voluntary provision of public goods and the collective control of natural resources; other potential applications include lobbying, political demonstrations, and popular uprisings. There has been considerable research on the subject from both a theoretical perspective and laboratory experimentation since the late 1970s.

Most of these studies share the following structure. There are  $N$  individuals. Each individual member,  $i$ , of the group, can take a costly action  $x_i \in X_i \subseteq \mathfrak{R}^+$ . The agent's payoff is  $U_i(x_i, x_{-i}) = A + G_i(y) - C_i(x_i)$  where  $y = \sum_{j=1}^n x_j$ ,  $A$  is a constant, and  $G_i$  and  $C_i$  are functions specifying the gains and costs of collective action for individual  $i$ . There are many variations on this theme, and the baseline version of these games without communication typically have individual decisions made simultaneously. Here we will also discuss variations which allow for pre-play communication or sequential choice, both of which introduce signaling opportunities.

We focus here on two specifications of the payoff structure. In a *linear voluntary contribution mechanism* (VCM),  $X_i = [0, W_i]$ ,  $A = c_i W_i$ ,  $G_i(y) = By$  and  $C_i(x_i) = c_i x_i$ . Group members for whom  $c_i > B$  have a dominant strategy to free ride on the contributions of others (i.e. choose  $x_i = 0$ ), and environments with such a payoff structure are basically souped-up  $n$ -person generalizations of the prisoner's dilemma. In a *binary contribution threshold public goods game*,  $X_i = \{0, 1\}$ ,  $A = c_i > 0$ ,  $G_i(y) = B > 0$  if  $y \geq K > 0$  and 0 otherwise, and  $C_i(x_i) = c_i x_i$ . In threshold public goods games where players do not have a dominant strategy ( $c_i < B$ ), there will usually be multiple equilibria and thus players face the combined strategic problems of free riding and coordination. For example, in the volunteer's dilemma (the special case of  $K = 1$ ) there are  $n$  (efficient) pure strategy equilibria where exactly one member contributes and all others free ride, as well as (inefficient) mixed equilibria.

There is a vast literature reporting the results of experiments designed to study the collective action problem, exploring different aspects of the problem, such as the effects of group size, heterogeneity, private information, payoff structure, and communication. Ledyard (1995) surveys the first two decades of research in this area, focusing mainly on VCM and threshold public goods games, and he identifies pre-play communication as one of several "strong effects" that has been shown in experiments to increase cooperation rates in VCM games.<sup>10</sup> He bases this conclusion on results from a diverse set of experimental stud-

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<sup>10</sup>The other two strong effects he notes are (1) group size; and (2) the ratio  $B/c_i$  (sometimes called the *marginal per capita return* from contributions). Observed cooperation rates tend to be higher in smaller groups and increasing in  $B/c_i$ .

ies reported by social psychologists, political scientists, and economists.<sup>11</sup> This important finding has been replicated in several studies since then, e.g. by Cason and Khan (1991).

The effects of communication in threshold public goods games are more subtle and complicated because of the interaction of free riding and coordination, and because of multiple equilibria. Several experiments have been reported with and without pre-play communication, where group members have heterogenous contribution costs, and these costs are private information. The per capita value of the public good is normalized as  $B = 1$ , and the individual contribution costs are independent draws from a commonly known uniform distribution on an interval  $[0, C]$ .

The symmetric Bayesian equilibria of the game without communication depend on  $N$ ,  $K$ , and  $C$ , and are characterized by a cutoff cost,  $c^*$ , which divides the members into contributors ( $c \leq c^*$ ) and non-contributors ( $c > c^*$ ). If  $K = 1$ , there is a unique symmetric equilibrium cutoff. If  $K > 1$ , except for some special boundary cases, there are two symmetric equilibria: an unstable equilibrium with  $c^* = 0$  and a stable equilibrium with  $c^* \in (0, C)$ . The stable equilibrium (in the sense of Palfrey and Rosenthal (1991a)) is characterized by an equation that says that, in equilibrium, a member with cost  $c^*$  is indifferent between contributing and not contributing:

$$c^* = \binom{N-1}{K-1} \left(\frac{c^*}{C}\right)^{K-1} \left(1 - \frac{c^*}{C}\right)^{N-K}. \quad (1)$$

The left side of the equation is the cost of contributing and the right side is the probability that a contribution will just reach the required threshold. There are also asymmetric equilibria, but in experiments are conducted with random re-matching and without communication essentially rules out any possibility to coordinate on such equilibria.

Palfrey and Rosenthal (1991a) reports the results of an experiment that compares behavior without communication to behavior with one round of binary pre-play communication, for the case of  $N = 3$ ,  $K = 2$ , and  $C = 1.5$ . The design used random rematching and each session consisted of 20 rounds of play. The stable Bayesian equilibrium in the game without communication can be solved using equation 1, yielding  $c^* = .375$ .

In the cheap-talk stage of the communication sessions, each member of the group, after observing their private cost, broadcasts a message to the other members of the group, stating that they intend to contribute or they do not intend to contribute. In the second stage of the game, after observing the intent messages of all members of their group, each member simultaneously makes a binding contribution decision. A perfect Bayesian equilibrium can be constructed where the cheap talk in the first stage is informative, and it takes the following form: There is a cutoff cost in the communication stage equal to  $c_c^* = .723$ . In the second stage, if exactly two members of the group said they intend to contribute in the cheap talk stage, they follow through on that intent and the third member does not contribute. If less than two players said they intend to contribute, then nobody contributes in the second stage. If all three members said they intend to contribute, then they follow a cutoff strategy in the

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<sup>11</sup>These studies include Dawes et al. (1977), Isaac et al. (1985), Isaac and Walker (1988, 1991), and Orbell et al. (1988). Sally's (1995) meta-analysis of reports a similar effect of communication in prisoner's dilemma games.

continuation game, where the cutoff cost is  $c_3^* = .461$ .<sup>12</sup> Theoretically, this leads to greater efficiency than the equilibrium with no communication.

The results are mixed. Subjects actually contribute nearly 50% more frequently than the stable equilibrium in the game without communication, and for this reason there was no significant efficiency gain from pre-play communication. On the other hand, subjects do successfully communicate in the cheap talk game, and the pattern of behavior in both the cheap talk stage and the final contribution stage is roughly in line with the constructed cheap talk equilibrium.

In a more recent experiment, Palfrey et al. (2017) extend this design by considering three different message spaces at the communication stage: binary “intent” messages as before; numerical revelation of private cost; and unrestricted communication via computer chat. In addition to the  $C = 1.5$  distribution of costs, they also obtain data for  $C = 1.0$ . As in the earlier study there are no significant efficiency gains from cheap talk using binary “intent” messages, and that turns out also to be the case with the somewhat richer message space where group members broadcast private cost announcements. Only with the very rich message space with unrestricted (but not face-to-face) communication is a significant improvement observed.<sup>13</sup> In fact, for the  $C = 1.0$  groups, unrestricted communication leads to the highest possible efficiency consistent with any equilibrium of the game.<sup>14</sup> Unrestricted communication also leads to efficiency gains for the  $C = 1.0$  groups, which are only slightly less than the theoretical efficiency bound.

Experiments on collective action games have been generally conducted in environments with few subjects, and communication between subjects, whenever considered, has reached all subjects. When thinking about applications such as revolutions, political demonstrations, and change in social or cultural norms, both features of the extant literature may be restrictive. In particular, in those applications the fact that an individual has only a small impact on the collective decision is an essential ingredient of the problem. Similarly, because of political repression or political correctness, restricted networks of communication may be appropriate to study such environments. Costly messages, or the opportunity to observe previous decisions (as in Lohmann (1994) work on costly political action), are obviously of interest in this regard, and are far from being thoroughly explored in the lab. For instance, changes in the technology of communication like the spread of participation in social networks have been considered as an important factor in several protest movements. It may be enlightening to explore the role of similarly cheapening private or public messages in games of collective action with many players in the lab.

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<sup>12</sup>This latter cutoff is calculated using equation 1, with  $C = .723$ .

<sup>13</sup>This mirrors a result that has been reported for cheap talk communication in VCM games. Bochet et al. (2006) report that the exchange of numerical information about intended contributions in a VCM game does not lead to increased contributions relative to no communication; but unrestricted natural language communication has a significant positive effect.

<sup>14</sup>Palfrey et al. (2017) use a mechanism design approach to characterize ex ante efficiency gains from pre-play communication in threshold public goods games with privately known contribution costs.

## 4 Multicandidate elections

Voter coordination in multicandidate elections has received interest in theoretical political science since the work of Riker (1982) and Palfrey (1989), inspired by the Duverger (1954) observation of a tendency for two-party systems to emerge in single-member district winner-take-all elections. Consider the following (complete information) game, adapted from Myerson and Weber (1993):  $N$  voters,  $i = 1, \dots, N$  must decide between three alternatives,  $A$ ,  $B$  and  $C$ . There are three types of voters, labeled like the alternatives, with  $N_X$  voters of type  $X$  for  $X = A, B, C$ . Each voter must either cast a vote for one of the alternatives, or abstain. The voting rule is simple plurality, so the alternative with most votes wins the election, with ties broken by the toss of a fair coin. The payoffs voters, as a function of voter type and the winner of the election are given by:

	type A	type B	type C
A wins	1	$b$	0
B wins	$b$	1	0
C wins	0	0	1

where  $b \in (0, 1)$  and  $N_C/2 < N_A = N_B < N_C$ . Thus, voters of type  $A$  and type  $B$  are jointly in the majority and have an incentive to coordinate their vote and defeat the minority candidate  $C$ , but this is complicated because a plurality of voters are type  $C$ . Voting is assumed to be costless. In every undominated pure strategy Nash equilibrium of this game, type  $C$  voters vote for  $C$ , but voters of type  $A$  and type  $B$  can distribute their votes between the two majority alternatives in many different ways consistent with equilibrium behavior. Most attention in the literature has been devoted to the *Duvergerian equilibria* in which all majority voters coordinate on the same alternative, either  $A$  or  $B$ , thus electing that alternative, and the *sincere equilibrium* in which all voters vote for their favorite alternatives, thus electing alternative  $C$ .<sup>15</sup> Note that alternative  $C$  is also a Condorcet loser, that is an alternative that would lose a one-on-one election against either other alternative. It is also the only suboptimal alternative from a utilitarian perspective as long as  $b$  is close enough to one. Thus, the Duvergerian equilibria are often considered more attractive than the sincere one from a social optimality point of view.<sup>16</sup>

Myerson and Weber (1993) introduce the concept of *voting equilibria* in multicandidate election games, a strategic equilibrium concept where voters are assumed to perceive the likelihood of near two-way ties as proportional to the vote share differences induced by the strategy profile, with the probability of ties being possibly the result of a (vanishingly small) amount of noise in preferences.<sup>17</sup> In the context of the environment considered above,

<sup>15</sup>A preference profile with a similar coordination problem was considered in the earliest debates in social choice by Borda (1784), where sincere voting behavior is implicitly assumed.

<sup>16</sup>It is worth pointing out that in a repeated setting, though, the possibility of an important minority alternative *never* winning the election would be distressing. (See e.g., Gerber et al. (1998) and Guinier (1994).)

<sup>17</sup>Explicit uncertainty about the support for each candidate is offered by the concept of large Poisson games (Myerson, 1998). Population uncertainty with large populations, however, would be hard to implement in the lab.

that is under simple plurality, the three voting equilibria of the game are precisely the two Duvergerian equilibria and the sincere equilibrium. Myerson and Weber (1993) also consider voting equilibria under approval voting and under Borda voting rule, which have also been examined in laboratory experiments; we focus the discussion in the simple plurality rule, which is most commonly employed, together with plurality runoff.

One focus of experimental work on multicandidate elections has been to identify conditions under which communication among voters might enable coordination on Duvergerian equilibria over those of the sincere equilibrium. Forsythe et al. (1993, 1996) compare elections with and without preelection polls in a setting with  $N_A = N_B = 4$  and  $N_C = 6$ , with either repeated play or reshuffling of the electorate. The experiments indicate that without polls or repeat play, the Condorcet loser wins the vast majority of elections, but there is a steep decline in the probability of the Condorcet loser winning the election when polls are introduced. That is, for Duvergerian equilibria to emerge, majority voters need to find a way to coordinate their behavior. Pre-election polls (or a shared history in the case of repeated play) provide this coordination benefit. Successful coordination among majority voters takes time to attain and is not perfect, but strategic coordination does better than sincere behavior according to Selten's measure of predictive success when polls are allowed. The mechanism by which this happens is that  $A$  and  $B$  voters tend to vote for whichever of the two alternatives is ahead in the polls. To the extent that there is some randomness in how voters announce their intentions in the poll, usually  $A$  or  $B$  do not tie in the polls. Thus polls, while not solving the coordination problem perfectly, are an effective means to achieve frequent coordination.

Using the same preference configuration, Reitz et al. (1998) introduce campaign contributions as another possible signaling device that enables coordination among voters. In that experiment, voters can pay a cost to advocate for one or several alternatives. They find that some voters do recognize this important coordination role of campaign financing, contributing to candidates they would like to win. This strategic behavior, in turn, leads to behavior resembling the Duvergerian equilibria. In all three coordination facilitating devices - polls, shared history of past elections, and campaigns - the key is in providing a way to break the ex ante symmetry between the two majority alternatives,  $A$  and  $B$ .

Kittel et al. (2014) introduce costly voting with private, heterogeneous costs (as in Levine and Palfrey (2007)) and unrestricted communication via free-form chat before voting in multicandidate elections. To focus on the problem of majority voters, minority votes were casted by a computer. The effect of communication on the probability of the minority alternative winning the election is impressive: it drops from nearly 50% to 20.6%, a clear indication of the advantage of communication for strategic behavior in collective settings. This is a result of both voter coordination and larger turnout by majority voters.<sup>18</sup>

Bouton et al. (2017) consider a situation with preference uncertainty in which voters do not know the size of the support of each majority alternative, that is,  $N_A$  and  $N_B$  are random. They compare a situation in which voters are informed of the realized values of  $N_A$  and  $N_B$  with a situation in which they are not informed. In line with previous literature, we can inter-

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<sup>18</sup>Kittel et al. (2014) do not characterize equilibrium behavior, which is a complex (and to our knowledge, unsolved) problem in their setting.

pret the signal received by voters as a poll. Bouton et al. use as a selection criterion a concept of strategic stability following Palfrey and Rosenthal (1991a) and Fey (1997) which selects both sincere and Duvergerian equilibria without polls, but only Duvergerian equilibria with polls. Looking at individual strategies, they find that indeed without polls sincere behavior is modal, while behavior consistent with Duvergerian equilibria is modal when polls are available.

Morton and Williams (1999) consider sequential voting in a multicandidate election with three voters and the following payoff structure:

	type A	type B	type C
A wins	1	$b$	0
B wins	$b$	1	$b$
C wins	0	$b$	1

where  $b \in (0, 1)$  and that the probability of each voter being of type A or C are equal, and larger than the probability of each voter being of type B. That is, B is the *expected Condorcet winner* (i.e., B would defeat each of the other alternatives in a head-to-head election with many voters) but may not be the realized one because of small numbers. In the lab, they find that under sequential voting later voters make use of the information revealed by earlier ones, who tend to vote informatively. Under some conditions, this lead to sequential voting selecting the expected Condorcet winner more often.

Tyszler and Schram (2011, 2013) consider a more general form of preference uncertainty in multicandidate elections, so that every ordinal preference profile over the three alternatives (including Condorcet cycling, where every alternative is defeated by some other alternative in a head-to-head election) has positive probability. They compare a situation in which voters are informed of the realized support for each candidate (interpreted as a poll) with a situation in which they are not, for several different values of  $b$ . A strategic vote is defined as a vote for the second-ranked alternative. As it is generally the case in voting games, there is multiplicity of Nash equilibria; Schram and Tyszler adopt as a selection criterion the limit Quantal Response Equilibrium as noise diminishes to zero, as in the general Logit solution proposed by McKelvey and Palfrey (1995). The Quantal Response Equilibrium captures the main qualitative features of aggregate behavior fairly well: the frequency of strategic voting increases with the value of the second-ranked alternative; and strategic voting increases with the availability of information when the value of the second-ranked alternative is high.

Summing up, under a wide range of conditions and environments, experimental evidence shows that the availability of information via polls, free communication, costly contributions, or a shared history enables the kind of strategic behavior described by Duvergerian equilibria. Some (not mutually exclusive) explanations for this behavioral pattern are noisy beliefs on preferences and decisiveness as in the concept of voting equilibria of Myerson and Weber (1993), tatonnement learning as in the concept of stability of Palfrey and Rosenthal (1991a) and Fey (1997), and selection by small mistakes as in McKelvey and Palfrey (1995). Disentangling the roles of these different coordination-enhancing factors presents an interesting and challenging research opportunity.



## 5 Elections with imperfect information

Consider the canonical Hotelling-Downs spatial model of electoral competition, described as an extensive form game. There are  $N + 2$  players. The first two players,  $A$  and  $B$ , are candidates, and choose simultaneously their policy platforms,  $x_A \in \mathfrak{R}_+$  and  $x_B \in \mathfrak{R}_+$ . The remainder of the players,  $i = 1, \dots, N$  are voters, and after candidates have chosen platforms, get to cast a vote either for  $A$  or for  $B$ . The voting rule is simple plurality, so the politician with most votes wins the election, with ties broken by the toss of a fair coin. The payoffs of the players are given by

	$A$	$B$	voter $i$
$A$ wins	1	0	$- x_A - x_i $
$B$ wins	0	1	$- x_B - x_i $

The parameter  $x_i$  represents the ideal policy of voter  $i$ . As is well known, if the median of the voters' ideal policies is common knowledge and candidates maximize the probability of winning, then, in any subgame perfect equilibrium where voters do not play weakly dominated strategies, both candidates adopt the median ideal policy as their platform—that is, the famous median voter theorem of Downs (1957) holds.

A remarkable series of articles, McKelvey and Ordeshook (1984b, 1985a,b, 1987), summarized in McKelvey and Ordeshook (1990), report experimental results of several different implementations of this game.<sup>19</sup> Most relevant to this survey, McKelvey and Ordeshook (1985a) studies a multiperiod model of elections. Candidates are not informed of the location of the ideal policies of voters, which are kept fixed across periods. In every period, candidates choose their platforms, and after that there is a sequence of two polls, in which voters are asked which of the two candidates they support. Approximately half the voters are informed of the location of the policy platforms of the candidates, and the remainder are told only which candidate is further to the left. All voters observe the polls, though, so even those who are not perfectly informed can make inferences about the location of the platforms. Theoretically, in a fulfilled expectations equilibrium (McKelvey and Ordeshook, 1985b),<sup>20</sup> candidates' platforms are equal to the median ideal policy. The lab implementation had between forty and fifty voters and two candidates in each experiment. In the experiments, about  $\frac{2}{3}$  of the uninformed voters were able to make inferences about the platforms of the candidates on the basis of the poll data, and the policy platforms converged to somewhere in between the median of the ideal policies for informed voters and the media for the whole electorate, but closer to the last one. This offers qualified support for the theoretical result that communication between voters via polls allows the perfect information game predictions to hold.

Another canonical environment for the study of elections is the dynamic model of electoral accountability, which exists in several variations. We can describe a simple two-period

<sup>19</sup>McKelvey and Ordeshook's work was anticipated by Plott (1991), who conducted experiments in the late 1970s with imperfectly informed politicians learning about policy preferences of voters via polls.

<sup>20</sup>The informational requirements of the equilibrium notion are similar to the later developed concept of self-confirming equilibrium (Fudenberg and Levine, 1993).

version as an extensive form game of incomplete information, as in Duggan and Martinelli (2015).<sup>21</sup> There are  $N + 2$  players. The first two players are the incumbent candidate and the challenger, and the remainder of the players are voters. The incumbent chooses first a level of effort. The incumbent's effort and the quality of the incumbent, decided by nature, determine a level of output. After output is realized, voters decide to reelect the incumbent or elect instead the challenger. Candidates like to be in office but dislike exerting effort, while voters like output, which depends positively on the candidate effort and quality. Neither effort or quality are observed directly by voters, who must make inferences on the basis of the realized output. The model intends to portray the working of the reelection motive in ensuring that democratic government is responsive to voters' preferences in the presence of moral hazard.

Dasgupta and Williams (2002) study a version of the electoral accountability model in which the incumbent decides on the level of effort without observing his or her own quality. The output of the incumbent, which voters value, depend on both the effort and quality of the incumbent in a positive way. Only a fraction of the voters are informed about the output of a novice incumbent, but before the election there is a sequence of repeated polls in which voters can reveal whether they would prefer to retain the incumbent or replace him with an unknown challenger candidate. As in McKelvey and Ordeshook (1985a), in a fulfilled expectations equilibrium, uninformed voters behave as if they were informed, and the incumbent plays a best response accordingly, exercising effort if the cost is low enough. In the lab implementation, ten rounds are conducted with the novice incumbent quality being determined again before every election. Fifteen voters were split in three equal-sized groups with different preferences over the politicians, and three voters of each group were informed about the incumbent output before the preelection polls. Note that informed voters were expected to make inferences about the incumbent quality on the basis of observed output, while uninformed voters could only make inferences on the basis of polls. Dasgupta and Williams (2002) results are generally consistent with the predictions of the fulfilled expectations equilibrium: uninformed voters making inferences solely on the basis of aggregate information revealed in the poll seem to do as well as informed voters.

In a slightly different vein, Lupia (1994) studies a spatial environment in which a politician can propose, at a cost, an alternative to the status quo. The politician and the voters have different ideal policies; the politician's ideal policy, in particular, is private information. If the proposal cannot be observed by voters, the politician will have a strong incentive to propose her ideal policy. Voters, however, can make inferences about the ideal policy of the politician since entry is costly, and use those inferences to support the politician's proposal or the status quo. Lupia's model can be reinterpreted as an electoral accountability model, with the proposing politician playing the role of the incumbent, and the status quo the role of the challenger. Evidence from the lab experiments reported in Lupia (1994) confirm that voters do indeed update their beliefs taking into account the information revealed by the entry decision.

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<sup>21</sup>Pioneering work on dynamic models of electoral accountability was done by Barro (1973), Ferejohn (1986), and Fearon (1999); see Duggan and Martinelli (2017) for a general overview.

Houser and Stratmann (2008) and Houser et al. (2011, 2016) present a model in which candidates have fixed policy platforms, but voters do not know which of the two is better. Candidates choose whether or not to engage in truthful advertising, and an election follows. Houser and coauthors take different versions of this model to the lab, including costless and costly advertising, and voluntary and mandatory voting. A bit surprisingly, voluntary voting (which would allow uninformed voters to abstain) does not seem to lead to better electoral outcomes than mandatory voting. In this study, costless advertising works effectively in attaining good electoral outcomes. They also find that even small probabilities of deceptive campaign advertising may have significant negative effects on voting welfare through voters' disposition to vote against candidates who advertise.

Summarizing, experimental results indicate that there are reasonable conditions under which democratic accountability can be achieved even if only a fraction of the electorate is informed, both in the sense of candidate convergence to desirable policies for the median voter (McKelvey and Ordeshook, 1990) and in the sense of providing good incentives to politicians in office, and reelecting higher quality incumbents (Dasgupta and Williams, 2002). Particularly noteworthy is the finding of a disciplining role of preelection polls and approval ratings on politicians reported by McKelvey and Ordeshook (1985a). Nonetheless, several important issues related to democratic accountability remain understudied in the lab. We specifically identify two such issues: (i) the role of entry decisions, and (ii) the role of media and other sources of information for voters. With respect to the first issue, an effective device for democratic accountability is the threat of entry by strong challengers, and exploring the effect of entry incentives both theoretically and in the lab is worth pursuing. With respect to the second issue, there is by now a burgeoning literature on the role of both traditional and social media in democratic accountability. Issues such as multiple media outlets, audience segregation, etc., may be implemented in the lab as pre-play communication in incomplete or endogenous networks. Similarly, the influence of experts and opinion leaders (as in Herrera and Martinelli (2006)) can be explored. In the same vein, endogenous information acquisition has not been studied in the lab in connection with democratic accountability, as the assignment of informed and uninformed voters has been treated as exogenous.<sup>22</sup> Information acquisition and transmission among voters is a promising area of research especially in connection with the current interest on the impact of misinformation and fake news on the working of democracy.

## 6 Information aggregation in juries and committees

In the last few decades, much attention has been devoted in the theoretical and experimental literature to information aggregation by voting in juries and committees with common or nearly common interests, a problem that goes back to Condorcet (1785). Consider the following Bayesian game, adapted from Austen-Smith and Banks (1996), who were the first to formulate a game theoretic model of this setting. There are a pair of alternatives,  $A$  and  $B$ ,

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<sup>22</sup>See the one voter environment of Dasgupta and Williams (1995) as an attempt in this direction and the references in the next section.

and a pair of possible states of the world, also labelled  $A$  and  $B$ .  $N$  voters,  $i = 1, \dots, N$  have common preferences over the alternatives, conditional on the state; they obtain a payoff of 1 if the chosen alternative matches the state and of 0 otherwise. Voters do not know which of the states is realized; they have some common prior beliefs,  $\pi$ , that the state is  $A$ , and each of them receives privately an informative signal binary signal,  $s \in \{a, b\}$  about the state of the world, where  $\Pr\{a|A\} = q_a > .5$  and  $\Pr\{b|B\} = q_b > .5$ . Voters must cast a vote for one of the alternatives. The voting rule is qualified majority, with  $A$  winning if and only if  $A$  receives more than  $k$  votes, where we assume  $k \geq (N - 1)/2$ . Thus, for example, majority rule corresponds to  $k = N/2$  and unanimity rule corresponds to  $k = N - 1$ . Preferences are such that voters receive a payoff of 1 if the outcome of the vote matches the state and a payoff of 0 otherwise. This is the standard *Condorcet jury* environment.

Austen-Smith and Banks show that *sincere voting* (e.g. voting for the better of two alternatives according to one's private information) is generally inconsistent with equilibrium; best-responding voters must condition their behavior on the event of being decisive, which quite generally leads to incentives for strategic voting.<sup>23</sup> Since decisive events are determined by the voting rule, it follows that strategic behavior will vary widely with different electoral institutions. A theoretical literature has explored Bayesian equilibria of the game just described in a variety of settings. In particular, Feddersen and Pesendorfer (1996, 1997, 1998) prove three important results: less informed voters have incentives to abstain (the *swing voter's curse*), sincere voting is not an equilibrium when a unanimous jury is required for conviction, and large elections under majority rule and other supermajority rules (other than unanimity) fully aggregate dispersed information.

Experimental work dealing with pre-play activities falls in three lines. The first line is concerned with the straightforward introduction of communication before voting, either unrestricted or via a message space. The second line is concerned with sequential voting, which allows voters to observe the behavior of previous players. The third line is concerned with costly information activities by players before voting. We consider them in turn next.

With respect to first line, it is reasonable to expect that opportunities for communication before voting, allowing voters to potentially share their private information, will have significant consequences for individual behavior and for the outcome of the election. Similarly, committees often use straw votes without commitment to gauge the support of motions that have been proposed, which is another form of pre-vote communication. Guarnaschelli et al. (2000) conduct an experiment to study voting behavior in Condorcet jury environments with three and six member committees, comparing majority rule and unanimity rule. Particularly relevant for this discussion, they also conducted treatments where a straw vote took place prior to the actual vote. Theoretically, the best Nash equilibrium with communication leads to perfect information aggregation under both voting rules, but without communication the Nash equilibrium is inefficient and fails to aggregate information under unanimity rule.<sup>24</sup> Under unanimity rule ( $k = N - 1$ ), they find clear evidence of strategic behavior when polls

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<sup>23</sup>In fact, for all  $\alpha \in (0, 1)$  and for almost all values of  $\pi, q_a, q_b$ , if the voting rule is  $k = \lceil \alpha N \rceil$ , then there is strategic voting in equilibrium when  $N$  is sufficiently large.

<sup>24</sup>See Coughlan (2000) and Gerardi and Yariv (2005).

are unavailable, which results in a significant loss of efficiency. In contrast, with a straw vote, voters use the straw poll to reveal their signals and hence the outcome of the straw vote coordinates the final vote on whichever alternative "won" the straw vote. The subjects in the experiment do not coordinate perfectly, but outcomes approximate the full information vote that would arise if all voters were able to observe all the other voters' signals. This leads to significant improvement in information aggregation and efficiency, with the effect being especially large in magnitude when the state of the world is  $A$ . Under majority rule, there should be no theoretical effects of communication on behavior. This is borne out in the data, where the effect on both behavior and outcomes is small and for the most part not significant. This is not surprising because there was very little strategic voting without communication and hence outcomes were nearly efficient.<sup>25</sup> Guarnaschelli et al. (2000) also find that the logit version of Quantal Response Equilibrium provides a good fit for the voting behavior of subjects in the lab, explaining in particular the findings (against Feddersen and Pesendorfer (1998) prediction) that convicting innocents is less likely under unanimity rule than under majority rule, and that there is strategic voting in the majority rule treatment with six member committees.

Goeree and Yariv (2011) study experimentally a setting like the one just described with nine member groups, allowing for deviations from common interests and considering different voting rules, with and without a round of free-form communication rather than a straw poll. Without the ability to communicate, agents behave in a strategic manner, similar to the findings previously reported in Guarnaschelli et al. (2000). In particular, they vote strategically when sincere voting is not a Bayesian equilibrium of the game. When communication is available, institutional differences matter less, and the efficiency in group decisions improves. With pure common interests, in particular, there are no significant differences between outcomes under different voting rules, and groups make welfare maximizing decisions given the available pooled information of the voters.

With regard to the second line of research, Hung and Plott (2000) considers, among other environments, a jury setting with sequential voting with ten voter electorates. They find that the pattern of behavior is consistent with Bayesian equilibrium predictions. In particular, there are information cascades, in the sense that later voters in the sequence tend to vote according to the pattern of earlier votes rather than following their private signal. This can be interpreted as a *bandwagon* effect or a preference for conformity.<sup>26</sup>

Pogorelskiy and Shum (2017) consider the effect of communication if voters are weak partisans. They are partisans in the sense that without information half the voters strictly

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<sup>25</sup>Most of the strategic voting under majority rule occurred in the six-member committees by voters with a  $B$  signal, but this is not surprising. In the majority treatment with six voters, ties were broken in favor of alternative  $B$ , so effectively it was 2/3 rule. This implies that the Nash equilibrium is weak: voters with a  $B$  signal are indifferent between voting for  $A$  or  $B$ .

<sup>26</sup>In the same spirit, in a setting of individual decisions, Goeree and Yariv (2015) allow subjects to choose between observing the past actions of other subjects, which has no instrumentally useful value, or observing an informative signal. They find a large fraction of individuals prefer the social (instrumentally useless) information, evidence of a preference for conformity that deserves to be further explored in collective decision settings.

prefer alternative *A* and half the voters strictly prefer alternative *B*. They are weak partisans in the sense that with full information all voters have common interests and prefer the alternative that matches the state. Hence, the efficient solution is to always choose the alternative that matches the state. As in Guarnaschelli et al., each subject receives a signal according to a signal technology that is common knowledge among the voters. The voters then have an opportunity to broadcast their signal (truthfully) to all their neighbors in a communication network. Their experimental design varies both the signal technology and the communication network. Three networks are considered: the null network; the complete network; and a polarized network which is complete within each party but with no links between voters of different parties. Three signal technologies are considered: the standard one, where each voter independently draws binary signal that matches the state with probability .7 (no bias); an uninformative signal that matches the voters ex ante preferred alternative with probability .7, regardless of the state (extreme bias); and a signal that is biased in favor of a voter's preferred alternative, but is still informative (moderate bias). The different signal technologies are interpreted as a bias in the media sources that voters follow, and the different network structures are intended to model the effect of information exchange via social networks. The obtain a number of interesting results. Two key findings are that (1) media bias of either kind (extreme or moderate) reduces efficiency; and (2) sharing signals through a network—either polarized or complete— increases efficiency relative to the empty network.

Battaglini et al. (2007) compare the behavior of voters in simultaneous versus sequential voting in the jury setting with either nine or twelve voters. They introduce costly voting so that equilibrium predictions differ depending on the voting protocol. In equilibrium, strategic abstention should increase in probability with the cost of voting under simultaneous voting, while higher voting costs should lead to free riding by early voters. The findings of the experiment are consistent with the qualitative effect of voting costs, although not with the quantitative predictions. In particular, under simultaneous voting there is more abstention than predicted with low costs, and more abstention than predicted with high costs. Similarly, under sequential voting, abstention by early voters increases with voting costs but far less than predicted. Due to the direction of this divergence, Quantal Response equilibrium provides a much better match with the data than Bayesian equilibrium. Sequential voting was found to have an advantage over simultaneous voting in terms of economic and informational efficiency, which is consistent with perfect Bayesian equilibrium,.

Ali et al. (2008) also compare the behavior of voters in simultaneous versus sequential voting in the jury setting but consider smaller committees, with either three or six voters; unlike Battaglini et al. (2007), they focus in unanimity rule and compare “ad hoc committees” which are re-matched of the experiment with “standing committees” which are kept together for several rounds. In agreement with the results of Feddersen and Pesendorfer (1998), they find a tendency for voters to behave strategically after receiving a signal favoring the status quo alternative. They also conclude that standing committees do not exhibit qualitatively different behavior than ad hoc committees, which suggests that behavior in these environments is somewhat robust to repeated interaction. This tentative conclusion probably warrants further research, in order to get a clearer picture of effect of repeated play and to better understand what conditions repeated play may or may not be an important factor.

With respect to the third line of research, we can imagine voters needing to engage in some costly effort in order to become informed about the issues before the committee proceedings (or in an election), with voters sorting strategically in the extent to which they gather information, depending on idiosyncratic costs. This setting is studied theoretically by Martinelli (2006, 2007), who shows that large elections can fully aggregate information under majority rule even if information is costly. That is, *rational ignorance* at the individual level can still result in consistent with normatively good information aggregation results. Elbittar et al. (2016) investigate these questions experimentally, based on that model. In their laboratory implementation, electorates of three and seven voters are considered under majority rule and unanimity rule, with abstention. Before voting, voters learn their idiosyncratic cost of information, and decide privately whether to acquire information or not. Information comes in the form of a private, noisy signal of the state. Bayesian equilibrium under majority rule has a simple form: when the cost of information is below an equilibrium cutoff, a voter acquires information and votes according to the signal received, and abstains otherwise. In the lab, as predicted by equilibrium, voters are more likely to acquire information under majority rule, and vote strategically under unanimity rule. However, a large fraction of voters vote when uninformed and acquire information very rarely, even with very low information costs. This results in a swing voter’s curse effect that significantly reduces group decision efficiency.

Großer and Seebauer (2016) study an environment similar to the one in Elbittar et al. (2016) under majority rule, and compare voluntary voting with mandatory voting. With voluntary voting, they observe a similar phenomenon as the one described above—committees with costly information suffer what the authors refer to as a *curse of uninformed voting*. Bhattacharya et al. (2017) revisit the environment, comparing treatments in which private signals are inconclusive (as in Elbittar et al. (2016) and Großer and Seebauer (2016)) with treatments in which they are conclusive, and varying a (uniform) cost of information acquisition. In line with previous results, they find that when private signals are noisy there is uninformed voting and there is no evidence of free riding effects as the electorate grows. Observed behavior is much more aligned with equilibrium predictions when signals are conclusive, including strong evidence of a group size effect. Bhattacharya et al. (2017) conjecture that individuals comprehend better free riding incentives when other individuals’ information is precise.

While much progress has been made, these experiments leave open several important questions and promising avenues for research. First, there is little evidence regarding the effects of larger numbers of voters (e.g. as in Levine and Palfrey (2007) or Battaglini et al. (2008)) on free riding in information acquisition and on information aggregation in general. One of the original motivations to study the jury environment since Condorcet (1785) was precisely the possibility of aggregating information that is highly dispersed in the society for good governance, and an old concern, tracing back to Condorcet (1785) as well, has been the problem of prejudice and bias being more prevalent in larger electorates. In this vein, the curse of the uninformed voter is a both a puzzling behavior that deserves to be probed more deeply in the lab and a practical concern for the working of democratic institutions.

## 7 Legislative bargaining

Legislative bargaining models offer a noncooperative game theoretic to studying voting environments in which the space of alternatives is multidimensional, such as distributive problems, so that median voter results like the one described in section 5 do not hold.<sup>27</sup> These bargaining models can be thought of as a way to endogenize the agenda formation process in committees, but specifying an extensive form game representation of the procedures according to which motions are placed on the floor for a vote by the entire committee. A canonical example is the following extensive form game, adapted from the seminal contribution by Baron and Ferejohn (1989). The committee is composed of  $N$  voters,  $i = 1, \dots, N$ , who must decide in how to divide a dollar; the set of possible division is given by  $X = \{x_1, \dots, x_N\}$ , with  $x_i \geq 0$  for  $i = 1, \dots, N$  and  $\sum_i x_i \leq 1$ . Time runs from  $t = 1$  to infinity; every period a voter, chosen at random with equal probabilities, is recognized to propose a division, which is subsequently put to a vote. If the proposal obtains a majority of the vote, it is implemented immediately and the game ends; otherwise a period elapses and a new voter is randomly recognized. Voters utility is linear in dollars and they are impatient, discounting the future according to a common discount factor  $\delta$ . Baron and Ferejohn (1989) study stationary subgame perfect (SSP) Nash equilibria of this game, and this is the equilibrium prediction that has guided most of the subsequent work on the subject. This canonical version of the model can be interpreted as a generalization of the Rubenstein (1982) model of two-person bargaining.<sup>28</sup>

Laboratory work on the legislative bargaining game has confirmed some of the SSP Nash equilibrium predictions. In particular, agreement tends to arrive without delay, with acceptance of the first proposal. Moreover, minimal winning coalitions are common, with the first proposer offering to split the pie almost exclusively with a bare majority of coalition partners, and the proposer typically gets a larger share than his coalition partners. The proposer share, however, is typically smaller than predicted by equilibrium, and often small token amounts are offered to non-coalition members (Palfrey, 2015). A possible explanation for these slight deviations from the SSP shares is the considerable uncertainty faced by the proposer about the motivations of potential coalition partners. To overcome this uncertainty, experiments have recently been conducted that add a stage preplay communication between the proposer and the other voters, which is in fact a feature of realistic bargaining situations. In the first such study, Agranov and Tergiman (2014) compare a treatment with preplay communication before a proposal is introduced with a treatment without communication in a laboratory implementation with  $N = 5$  and  $\delta = 0.8$ . The preplay communication was implemented by computerized chat, where subjects could send messages to any subset of other voters. Thus,

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<sup>27</sup>There has been some experimental work in connection to cooperative game predictions for coalitional bargaining situations, allowing for free communication; see e.g. Riker and Zavoina (1970), McKelvey and Ordeshook (1984a), Endersby (1993), and Bolton et al. (2003). Coalitional games are outside the scope of the Handbook.

<sup>28</sup>The first experiment on the Baron-Ferejohn model was conducted by McKelvey (1990). Experimental literature on other models of bargaining with rounds of communication includes the work of Roth and Erev (1995) on the ultimatum game and, closely related, the work of Andreoni and Rao (2011) on the dictator game.



they could engage in private conversations with specific other voters or could broadcast messages to the entire group (or a subset). In both treatments, the first proposal is accepted with very high probability; however, in the preplay communication treatment there is a significant increase in the rents going to the first proposer. Unrestricted communication helps align the experimental results with the theoretical predictions via two channels: it helps dispel some of the uncertainty surrounding the willingness of the potential coalition partners to accept lower offers, and promotes competition between possible coalition partners. The competition promoting effect seems particularly important because the communication stage allows gives bargaining power to the proposer. A second paper (Agranov and Tergiman 2016) explores the effect of communication in the same kind of bargaining game, except with a unanimous voting procedure instead of majority rule. This eliminates the competition between the coalition partners, and in doing so effectively "turns the table" against the proposer because any non-proposer can threaten to veto the proposal. This reversal of bargaining power is clearly observed in the experiment. With communication, exactly equal splits among all five committee members are observed more than 90% of the time—there is no proposer power. Without communication, in contrast, exactly equal splits among all five committee members are rarely observed, with the proposer gaining a larger share than the others more than 85% of the time—there is considerable proposer power.

Baranski and Kagel (2015) also consider rounds of preplay communication in a lab implementation with  $N = 3$  and no formal discounting. In the Baranski and Kagel protocol, communication occurs through bilateral, private conversations between the proposer and the two potential minimum winning coalition partners (closed door communication). As in the Agranov and Tergiman (2014) experiments, the result is a sharp increase in the share of the proposer, getting it close to equilibrium predictions. As a direct comparison with Agranov and Tergiman, they also consider a treatment where both private communication and publicly broadcast messages are allowed (open door), which also leads to an increase in the share of the proposer, but less than targeted communication.

Another branch of research on legislative bargaining considers a sequence of repeated divide-the-dollar bargaining games, where in each period a proposal is voted against an endogenous status quo, which was determined by the vote in the previous period (for example, Kalandrakis (2004)). The agenda process in each period is simplified compared to the Baron-Ferejohn protocol. One member of the committee is selected to be the proposer at the beginning of each period. If his proposal fails to win a majority, the status quo division determines the period payoff to all members of the committee, and continues as the status quo in the next period. If his proposal passes, it determines the period payoff to all members of the committee, and becomes the new status quo for the next period. Payoffs in the endogenous status quo game are equal to the discounted infinite sum of period payoffs. The theoretical focus is on the Markov perfect equilibria of this stochastic game. Battaglini and Palfrey (2012) report the first experiment to study such environments and consider several variations where the set of feasible divisions of the dollar are restricted. The equilibrium involves an evolution of the status quo over time that rotates randomly around a small set of inequalitarian outcomes, and the coalitions change randomly across periods. However, the observed outcomes are more egalitarian than predicted and there is persistence to the coalitions

that form. The latter observation is the starting point for Baron et al. (2017), which investigates the role of pre-play communication on the dynamics of outcomes and the durability of coalitions. Implementing a subset of the environments studied in Battaglini and Palfrey (2012), they compare three different communication protocols: no communication; private communication; and public communication. The outcomes with no communication are similar to Battaglini and Palfrey (2012). Pre-play communication produces durable coalitions more often and they are more durable than with no communication, but the outcomes are sensitive to the communication protocol. Private communication leads to more minimum winning coalitions and less egalitarian outcomes than with no communication, whereas the effect of public communication is exactly the opposite.

There is still much to do regarding the legislative bargaining game in the laboratory. As an illustration, consider a variation on the legislative bargaining game in which legislators have policy positions, so that coalitions are not purely distributive and can be interpreted as legislative parties, as in the model developed by Jackson and Moselle (2002) and investigated experimentally by Christiansen et al. (2013). In particular, it seems useful to explore if communication leads closer to the subgame perfect equilibrium prediction and away from egalitarian split between coalition partners.

## 8 Final remarks

The papers reviewed here show that communication and other kinds of pre-play actions can affect outcomes of voting games, elections, and collective action games in myriad ways. Upon closer inspection, however, one can identify a relatively small number of strong principal forces that can succinctly organize most of these diverse effects. We identify three such forces that appear to be operating: *equilibrium*, *efficiency*, and (underlying both) *coordination*.

When all three forces operate in the same direction, as in the case of defeating a Condorcet loser in multicandidate elections, the results are clear: pre-election communication in nearly any form (polls, shared history, campaigns) leads to coordination on an efficient equilibrium. In common value Condorcet jury voting environments, pre-play communication expands the set of equilibria, which enables voters to coordinate their voting strategies, resulting in full information aggregation and efficient outcomes, even under voting rules that would otherwise be highly inefficient. For somewhat different reasons, polling information allows for full information aggregation in spatial voting models as well, leading to Downsian candidate convergence to the ideal point of the median voter—the full information equilibrium outcome.

In games where there is a conflict between private interests and group efficiency, as in collective action problems, the results are more mixed. In binary contribution threshold public goods games, pre-play communication expands the set of equilibria and, if the communication structure is rich enough, leads to significant efficiency gains, as players can coordinate on the new, more efficient, equilibria of the expanded game. In linear VCM environments with communication, the forces of efficiency seem to overpower the strategic incentives in

equilibrium, at least in the short run, even though communication does not expand the set of equilibria. There is some evidence that these immediate gains may decay over time if subsequent plays of the game are not preceded by communication, as reported in Isaac and Walker (1988).

Legislative bargaining games have a more complicated equilibrium set, but pose less of a conflict between private gains and efficiency. In particular, while many versions of these games have a unique SSP equilibrium, the infinite horizon allows nearly any division of the pie to be supported as a subgame perfect equilibrium, using nonstationary strategies. But the forces of efficiency seem to play no role in the divide the dollar game; there is no delay in equilibrium, so there are only distributional consequences. The effect of communication in these games is to modify the relative bargaining power of the proposer and her potential coalition partners. With majority rule, pre-play communication induces competition between the possible coalition partners, which benefits the proposer resulting in very unequal divisions; but in unanimity games, any single non-proposer can “hold up” the proposer, so the tables are reversed and equal splits emerge as the norm. In environments where there are nondistributive policy issues, the effect of pre-play communication on behavior under majority rule may be less clear-cut, and this warrants further exploration in the laboratory.

Voter turnout games are even more complicated. If the two competing parties are equal in size, then communication leads to outcomes closer to the equilibrium of 100% turnout, but this is highly inefficient. If the two competing parties are unequal in size, then there are two sources of inefficiency to be resolved, and neither is consistent with efficiency or equilibrium. On the one hand, efficient outcomes would always have the majority party winning, but on the other hand efficiency requires as few voters as possible. The most efficient strategy profiles have exactly one majority voter voting and all other voters abstaining. But this is inconsistent with equilibrium voting behavior. In fact, in the absence of communication, equilibrium predicts an underdog effect, with higher turnout rates on the minority size—clearly inefficient. The experimental finding is that pre-play communication, either with polls or actual cheap talk communication among the voters, leads to a bandwagon effect for the majority party and what might be called a “discouragement” effect on the minority. As in the social dilemma literature, this can lead to efficiency gain if there is not too much over-voting by the majority, as the probability of a majority victory increases.

The experimental results available so far provide some clues about the effect of communication in public choice environments. Much work still remains to be done, however. We have pointed to some loose threads and open questions in the preceding sections. Among the many issues worth exploring experimentally, we would highlight a few. One particularly interesting avenue of research would be experiments that investigate collective action environments with many subjects and costly communication, resembling revolutions, uprising and cultural change. The details of the communication network are probably important in these contexts. Another important issue worth exploring experimentally is the role of voters’ information for democratic accountability. Beyond the seminal work of McKelvey and Ordeshook (1990), one may want to allow in the laboratory for the emergence of opinion leaders, for instance by allowing privately costly, unverifiable acquisition of information before communication between voters. Issues such as the emergence of opinion leaders and

the possibility of these opinion leaders strategically manipulating the beliefs of the other voters, are worth bringing to the lab. In concluding, we want to remark that in public choice as in other environments, experiments can be especially effective as research tools when connected to economic and game theory. This is well illustrated by the literature we have reviewed, and should be a guiding principle of the work to be done.

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