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

César Martinelli Thomas R. Palfrey

August 5, 2018

1 Introduction

Voting games and other collective decision situations pose particular challenges for game theory predictions. Often, there is a plethora of Nash equilibria, which makes if difficult for voters to best respond to each other. Voters may differ in their motivations, which may include prosocial 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 released. 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 by collective decision environments.

Laboratory experiments inspired by political situations seem uniquely qualified to throw light in the effects of pre-play activities on behavior in collective decision environments, since they allow the researcher some degree of control and observability of information acquisition and information flows among voters. Thus, experiments allow us to understand how voters achieve some order and may potentially help us in improving the design of environments for collective choice.

In this survey, we consider selectively lab experiments on voting games including pre-play activities. We consider as such 1) the release of information about realized preferences of voters, 2) public messages about voting intentions (akin to

*Martinelli: Department of Economics, George Mason University. Email: cmarti33@gmu.edu. Palfrey: California Institute of Technology. Email: trp@hss.caltech.edu.

pre election polls), 3) free form communication, 4) costly messages (representing variously campaigns, advertising, or costly entry), 5) sequential decisions (which allow some voters to observe other voters' actions), and 6) information acquisition activities. Formally, (2) and (3) are forms of cheap talk, which do not alter the set of equilibria of the games we consider but may serve to coordinate in particular equilibria. (1), (4), (5) and (6), instead, are alterations in the game form in directions that are interesting or realistic.

We focus the survey on five areas that have received much attention in the last few decades. These areas are 1) costly voting, 2) coordination in multicandidate elections, 3) electoral competition with imperfect information about politicians, 4) information aggregation in committees, and 5) legislative bargaining. We dedicate a section to each of these areas in the remainder of the paper. Table 1 offers an overview of the papers reviewed, classified by pre-play activities and research area.

A main lesson from the extant work is that, in spite of the difficulties referenced above, 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. Pre-play communication facilitates this, even in situations in which communication comes as nothing but cheap talk. While qualitative features predicted by (a selection of) Nash equilibrium hold in several environments, some quantitative predictions do not hold so well. Some of the literature is suggestive of a role for social preferences (for instance, a preference for being in the winning side) in these deviations.

The literature is also suggestive of a role for mistakes (as in Quantal Response equilibrium models) and difficulties in handling Bayesian updating in the presence of incomplete information (as predicated by behavioral theories). Mistakes and biases are not altogether surprising in environments in which there is little feedback and (often) a small probability of an individual voter 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 unobservable heterogeneity. In spite of these circumstances, game theory solution concepts by and large help organize and understand the observed behavior.

Voting is a fundamental institution to reach collective decisions, just as much as, say, voluntary exchange is a fundamental institution to achieve better allocations. The acquisition and transmission of information among voters is an integral part of what makes voting work well, when it does. Experimental literature, in combination with game theory, has helped throw some light on very old questions regarding voting. The literature surveyed is still evolving, and much work remains to be done. Further experimental work may help us disentangling the role of social preferences, mistakes, and biases in observed behavior, and to better understand

	preference information	voting intentions	free form communication	costly messages, sequential voting, information acquistion
costly voting	Großer and Schram (2010), Klor and Winter (2007, 2014)	Agranov et al. (2017)	Bornstein (1992), Schram and Sonnemans (1996), Großer and Schram (2006)	
multi-candidate elections	Bouton et al. (2017), Tyszler and Schram (2011, 2013)	Forsythe et al. (1993, 1996)	Kittel et al. (2014)	Reitz et al. (1998), Morton and Williams (1999)
elections with imperfect information		Plott (1991), McKelvey and Ordeshook (1985a), Dasgupta and Williams (2002)		Lupia (1994), Houser and Stratmann (2008), Houser et al. (2011)
information aggregation in committees		Guarnaschelli et al. (2000)	Goeree and Yariv (2011)	Hung and Plott (2000), Battaglini et al. (2007), Elbittar et al. (2016), Großer and Seebauer (2016), Bhattacharya et al. (2017)
legislative bargaining			Agranov and Tergiman (2014), Baranski and Kagel (2015)	

Table 1: Preplay activities in voting games

the role of pre-play communication in equilibrium selection.

2 Costly voting

The economic analysis of voting behavior starts in earnest with the work of Downs (1957), Tullock (1967) and Riker and Ordeshook (1968), and in particular with their 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 fully-fledged game model. N voters, $i = 1, \ldots, N$ 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 a fair draw. N_A voters favor alternative A and the remainder $N_B = N - N_A$ favor alternative B, with $N_A \geqslant N_B$. The following matrix describe the payoffs accruing to each voter as a function of the outcome of the election and whether the voter casted or not a vote:

	casts a vote	abstains
favorite alternative wins	1-c	1
favorite alternative loses	-c	0

$c \in (0, 1/2)$ represents the cost of voting. The game has pure strategy Nash equilibria only under extreme circumstances, like $N_A = N_B$, but it has many mixed strategy equilibria. A mixed strategy equilibrium that has received 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 between supporting their favorite alternative and abstaining with the same probability. 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 this profile is not a Nash equilibrium.

Palfrey and Rosenthal (1985) introduce private information about the cost for each voter in the costly voting game. A quasi-symmetric Bayesian equilibrium of this incomplete information game can be described by a pair of cutoff costs $(\overline{c}_A, \overline{c}_B)$, 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. Levine and Palfrey (2007) experimentally test the predictions of Palfrey and Rosenthal (1985); though they do not include communication or other pre play activities, their work sets a useful benchmark for the discussion of the literature. Levine and Palfrey find that subjects in minority vote with

higher frequency than subjects in the majority, an *underdog effect* predicted by the Bayesian equilibrium of the incomplete information game (and by the quasi symmetric equilibrium of the complete information game). They detect smaller than Bayesian equilibrium levels of turnout in smaller electorates, and larger than Bayesian equilibrium levels of turnout in large electorates (in particular, in their treatment with the largest electorate, 51 voters). This deviation from Bayesian equilibrium is consistent in direction with a Quantal Response equilibrium with a simple logit specification of the error structure, as in McKelvey and Palfrey (1995), but still exceeding it in magnitude.

The literature on preplay activities in the costly voting game has two strands. The first strand introduces rounds of (anonymous but free format) communication among voters in complete information situations in which $N_A = N_B$. This strand has been concerned with exploring the role that group identification or "civic duty" may have in determining turnout, a possible explanation of the substantial participation observed in mass elections which seems at odds with the game theoretic models described. The underlying idea is that communication may either help coordinating 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.

In the first strand, Bornstein (1992) introduces a round of communication in a public good provision game with intergroup conflict that resembles the costly voting game, and observes that intragroup communication does increase participation, while intergroup communication depresses it. Each competing group in Bornstein's experiments has three members; communication was introduced as a five minute discussion, taped by an experimenter, before subjects decides individually whether to contribute toward their group defeating the other. Schram and Sonnemans (1996) investigate the effects on turnout of communication in two costly voting games, one similar to Palfrey and Rosenthal (1983) and one in which 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, an before five last rounds, in a treatment in which groups were kept constant over consecutive elections. (Subjects were really playing a repeated game, which is a confounding factor.) Communication does exhibit a strong effect over turnout, increasing the average number of votes in each group from 1.42 to 2 in each of the teams under proportional representation, and from 1.23 to 3.73

under simple majority. Noteworthy, on both the Bornstein and Schram and Sonnemans (simple majority) experiments, with relatively small electorates, the pure strategy Nash equilibrium is for all subjects to vote. Thus, without communication there is undervoting, as observed also by Levine and Palfrey (2007), and intragroup communication leads in the direction of Nash equilibrium predictions.

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 in half, three senders and three receivers. Senders are allowed to vote early or late, while receivers can vote only late; each sender can tell (truthfully or not) with whom the sender is paired whether the sender has voted early. In the "strangers" treatment, subjects are reallocated to the two groups at the beginning of each round. When senders know they are paired with members of the same group, senders signal their preference for joint participation by voting early. Receivers, in turn, seemingly reciprocate a vote by their neighbor by voting themselves at much higher rates than after observing abstention. When neighbors belong to different groups, per contra, receivers seem to consider (rightfully) senders' messages to be uninformative, so they have no effect on turnout. In the "partners" treatment, per contra, subjects are kept together in the same group all rounds; in this case neighborhood information exchange among members of the same groups also raises turnout, though the mechanism does not seem to be reciprocity regarding senders. (As noted before, the partner environment has the inconvenience that subjects are really playing a repeated game.) In sum, intragroup local communication leads in the direction of pure strategy Nash equilibrium predictions regarding turnout.[1]

In the second strand, Großer and Schram (2010) 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. In particular, they consider a setting with twelve voters in which preferences are determined randomly in each found, with each group having at least three voters. They show that poll releases have strong effects on voter turnout. Most strikingly, and at odds with the quasi-symmetric equilibrium, when voters are informed turnout increases in the level of disagreement. Moreover, majority voters turn out at higher rates than the opposing minority voters. That is, there is a *bandwagon effect*. Klor and Winter (2007, 2014) perform a similar comparison in a setting with seven voters. In closely divided electorates they observe that voters in the majority vote with a significantly higher frequency than subjects in the minority, while in other electorates they do not observe signifi-

[1] In the public good game with voluntary contributions, Palfrey et al. (2017) provide experimental evidence that cheap talk help achieve efficient contributions subject to incentive compatibility constraints.

cant differences on the voting behavior. This behavior is at odds with the underdog effect predicted by the quasi-symmetric equilibrium.

Agranov et al. (2017) introduce actual polls in costly voting setting with nine voters and preference uncertainty. As opposed to previous experiments, voters make announcements about their voting intentions that may be truthful or not. Note that this implies that some uncertainty remains about the preferences of voters after communication. Again, they find a bandwagon effect: voting propensity increases systematically with subjects' predictions of their preferred alternative's advantage. This leads to more participation by the expected majority and generate more landslide elections.

Großer and Schram (2010), Klor and Winter (2007, 2014), and Agranov et al. (2017) consider environments in which costs of voting are homogeneous, as opposed to the private cost environment of Levine and Palfrey (2007). This introduces equilibrium multiplicity, and makes direct comparisons difficult.[2] (In Agranov et al. (2017), equilibrium multiplicity is compounded by strategic behavior in polls.). Taking cautiously the evidence on bandwagon effects, there are two likely 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); in the same line, Großer and Schram (2010) favor 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 like to vote for the winner provides a good fit to observed behavior. 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.

3 Multicandidate elections

Voter coordination in multicandidate elections has received interest in modern formal literature since the work of Riker (1982) and Palfrey (1989), inspired in turn on Duverger (1954) observation of a trend toward bipartisanism in democracies with winner-take-all elections. Consider the following (complete information) game,

[2] In the private cost environment, equilibrium uniqueness obtains for some parameter constellations.

adapted from Myerson and Weber (1993): N voters, $i = 1,\ldots,N$ 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 a fair draw. The payoff of a voter, as a function of the 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

We assume $b \in (0,1)$ and $N_C/2 < N_A = N_B < N_C$, so that voters of type A and type B are jointly in the majority and have an incentive to coordinate their vote and defeat the minority voters, that is type C. Note that voting is assumed costless. In every undominated pure strategy Nash equilibrium of this game, type C voters vote for C, but there 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 voter for 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.[3] Note that alternative C is a Condorcet loser, that is an alternative that would lose a one-to-one election against any other alternative. It is also the only suboptimal alternative from a utilitarian perspective as long as b is close enough to one, as often assumed in the literature. Thus, the Duvergerian equilibria are often considered more attractive than the sincere one from a social optimality point of view.[4]

Myerson and Weber (1993) introduce the concept of *voting equilibria* in multicandidate election games, an strategic equilibrium concept that requires that voters perceive the likelihood of near two-way ties as linearly proportional to the vote differences induced by the strategy profile, with the probability of ties being possibly the result of a (vanishingly small) amount of noise in preferences.[5] In the context of the game considered above, that is under simple plurality, the three voting

[3] A preference profile with a similar coordination problem was considered in the earliest debates in social choice by Borda (1784), who assumes implicitly sincere equilibrium behavior.

[4] 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).)

[5] Explicit uncertainty about the support for each candidate is offered by the concept of Poisson games introduced by Myerson (1998). Population uncertainty, however, seems hard to implement in the lab.

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 are also object of some attention in the experimental literature; we focus the discussion in the simple plurality rule, which is most commonly employed, together with plurality runoff.

A focus for experimental work on multicandidate elections has been to test whether communication among voters favor the predictions of 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 $N_C = 6$, and with repeated play or reshuffling of the electorate. The experiments indicate a steep decline in the probability of the minority alternative winning the election when polls are introduced. That is, for Duvergerian equilibria to emerge, majority voters necessitate to coordinate their behavior, and preelection polls, or a shared history in the case of repeated play, satisfy that requirement. 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. In similar setting, Reitz et al. (1998) introduce campaign contributions as another possible avenue for communication among voters. That is, they allow voters to costly 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.

Kittel et al. (2014) introduce costly voting with private, heterogenous 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 near 50% to 20.6%, as clear suggestion 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.[6]

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 support for each candidate with a situation in which they are not. In line with previous literature, we can refer to 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 (1991) and Fey (1997) which selects both sincere

[6]Kittel et al. (2014) do not characterize equilibrium behavior, which is a complex (and to our knowledge, unsolved) problem in their setting.

and Duvergerian equilibria without polls, and 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

They assume $b \in (0,1)$ 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* (would defeat each of the other alternatives in a head-to-head election) but may not be the realized one. 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, every alternative is defeated by some other alernative 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, under different assumptions about the degree with which voters value the second-ranked alternative in their preference ordering. 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 McKelvey and Palfrey (1995). The Quantal Response equilibrium predicts aggregate behavior fairly well; the frequency of strategic voting increases with the value of the second-ranked alternative, and it increases with the availability of information when the value of the second-ranked alternative is high.

Summing up, the experimental evidence supports under different conditions and that the availability of information via polls, free communication, costly contributions, or even a shared history favors the strategic behavior described by Duvergerian equilibria, though sincere behavior still occurs under those circumstances. 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 (1991) and Fey (1997), and selection by small mistakes as in McKelvey and Palfrey (1995). Disentangling the role of these different stories is an interesting and open question.

4 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 politicians, and choose simultaneously their policy platforms, $x_A \in \Re_+$ and $x_B \in \Re+$. The remainder of the players, $i = 1,\ldots,N$ are voters, and after politicians 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 a fair draw. The payoffs of the players are given by

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

The parameter x_i represents the ideal policy of voter i. As is well known, if the median of the ideal policies is unique, in any subgame perfect equilibrium in which voters do not play weakly dominated strategies, both politicians adopt the median ideal policy as their platform–that is, the famous median voter result of Downs (1957) holds.

In a remarkable series of articles, McKelvey and Ordeshook (1984b, 1985a,b, 1987), summarized in McKelvey and Ordeshook (1990), have studied different versions of this game as a game of imperfect information and taken them to the lab.[7] Most relevant to this survey, McKelvey and Ordeshook (1985a) studies a multiperiod model of elections. Politicians are not informed of the location of the ideal policies of voters, which are kept fixed across periods. In every period, politicians choose their platforms, and after that there is a sequence of two polls, in which voters are asked whom of the politicians they support. Approximately half the voters are informed of the location of the policy platforms of the politicians, and the remainder are told only which politician 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. McKelvey and Ordeshook show that, in a fulfilled expectations equilibrium,[8] politicians' platforms are equal to the

[7] McKelvey and Ordeshook's work was preceded by Plott (1991), who conducted experiments in the late 1970s with imperfectly informed politicians learning about policy preferences of voters via polls.

[8] The informational requirements of the equilibrium notion are similar to the later developed concept of self-confirming equilibrium (Fudenberg and Levine, 1993).

median ideal policy. The lab implementation had between forty and fifty subjects in each experiment. In the experiments, about $\frac{2}{3}$ of the uninformed voters were able to make inferences about the platforms of the politicians 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 theoretical result that communication between voters allows the perfect information game predictions to hold.

Another canonical environment for the study of elections is the dynamic model of electoral accountability. We can describe a simple two-period version as an extensive form game of incomplete information. There are $N+2$ players. The first two players are the incumbent politician 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. Politicians like to be in office and dislike exerting effort, while voters like output, which depends positively on the politician 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.[9]

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. Only a fraction of the voters are informed about the output of the politician, but before the election there is number of polls in which voters can reveal which politician they support. 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 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 quality, while uniformed voters were constrained to 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

[9] Pioneer work was done by Barro (1973) and Ferejohn (1986); see Duggan and Martinelli (2017) for a general overview.

basis of aggregate information revealed in the poll seem to do as well or even better than 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 conducted by Lupia (1994) seem to confirm that voters do indeed update their beliefs taking into account the information revealed by the entry decision.

Houser and Stratmann (2008) and Houser et al. (2011) present a model in which politicians have fixed policy platforms, but voters do not know which of the two is better. Politicians can engage in truthful advertising. 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. Costless advertising works very effectively in attaining good electoral outcomes.

Summarizing, experimental results indicate that democratic accountability can be achieved even if only a fraction of the electorate is informed, both in the sense of 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 politicians (Dasgupta and Williams, 2002). Note that in spite of being an important channel for democratic accountability, electoral incentives and politician selection remain understudied in the lab.

5 Information aggregation in committees

In the last few decades, much attention has been devoted in the theoretical and experimental literature to information aggregation 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 first formulate a game theoretic model of this setting. There are a pair of alternatives, A and B, and a pair of possible states of the world, also labelled A and B. N voters, $i = 1,\ldots,N$ 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 and each of them receives privately an informative signal about the state of the world. Voters must cast a vote for one of the alternatives; the alternative with most votes wins the election, with ties broken by a fair draw. Austen-Smith and Banks show that *sincere voting* (e.g. voting for the best alternative according to updated beliefs) is generally not an equilibrium profile; best-responding voters must condition their behavior on the event of being decisive. 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. The second line is concerned with sequential voting, which allows voters to observe the behavior of precedent players. The third line is concerned with costly information activities by players before voting. We consider them in turn next.

With respect to the first line, it is reasonable to expect that opportunities for communication before voting, allowing voters to potentially share their private information, will have deep consequences for individual behavior and for the outcome of the election. Guarnaschelli et al. (2000) study experimentally a jury setting like the one just described in three and six member groups, considering majority rule and unanimity rule, and an environment with a preelection poll versus one without. Under unanimity rule, they find clear evidence of strategic behavior when polls are unavailable. When polls are allowed, per contra, subjects for the most use the straw poll to reveal their signal, and voters vote with the (aggregate) public signal. Interestingly, under majority rule, preelection polls may lead to more strategic voting, since there is a residual of strategic revelation. Guarnaschelli et al. (2000) also find a good fit of a Quantal Response equilibrium for the behavior of subjects in the lab, explaining in particular the finding (against Feddersen and Pesendorfer (1998) prediction) that convicting innocents is less likely under unanimity rule than under majority rule.

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 com-

munication rather than polls. Without the ability to communicate, agents behave in a strategic manner as predicted by the theory. In particular, they eschew sincere voting when the Bayesian equilibrium requires them so. When communication is available, institutional differences matter less, and efficiency in group decision 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 information.

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 informational cascades, in the sense of (late voter) sequences of voting decisions that are consistent with the pattern of previous decisions but not with the private information held by later voters.[10]

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 voting timing. In particular, 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. Results in the lab agree with the direction of the effect of voting costs, although not with the quantitative predictions. In particular, under simultaneous voting there is mere 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 this divergence, Battaglini et al. (2007) find a much better fit of Quantal Response equilibrium than Bayesian equilibrium predictions. On agreement with predictions, sequential voting turns out to have an advantage over simultaneous voting in terms of economic and informational efficiency.

Ali et al. (2008) compare the behavior of voters in simultaneous versus sequential voting in the jury setting 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 voter 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

[10] 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.

that repeated interaction in this setting does not select for a different equilibrium.

With respect to the third line of research, we can imagine voters needing to pay some costly effort to get informed about the issues before the committee proceedings, with voters sorting strategically regarding information acquisition 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 is consistent with good information aggregation results. Elbittar et al. (2016) take to the lab a similar situation. In their lab 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, nonconclusive signal. Bayesian equilibrium under majority rule has a simple form: when the cost of information is below an equilibrium cutoff, voters should acquire information and vote according to the signal received, and should abstain otherwise. (Indeed, under quite general circumstances, best response behavior requires adopting such cutoff strategies.) 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 fraction of voters vote when uninformed and acquire information very rarely.

Großer and Seebauer (2016) study an environment similar to the one in Elbittar et al. (2016) under majority rule, and compare a situation in which voters are allowed to abstain (voluntary voting) with one in which they are not (mandatory voting). Under voluntary voting, they observe a similar phenomenon as the one described above–as they dab it, committees with costly information suffer 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 inconclusive there is uninformed voting and there is no evidence of free riding effects as the electorate grows. Behavior in the lab 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.

In concluding, the extant experimental literature in information aggregation leaves 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 harnessing information 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 proved more deeply in the lab and a a practical concern for the working of democratic institutions. Finally, endogenous information acquisition has not been studied in the lab in connection with democratic accountability,[11] an environment of interest especially in connection with the current interest on the impact of misinformation and fake news on the working of democracy.

6 Legislative bargaining

Related to the experimental work on voting, there has been some interest in experiments in legislative bargaining. Legislative bargaining models offer a (noncooperative) game prediction in situations in which the space of alternatives is multidimensional, such as distributive problems, so that median voter results like the one described in section 4 do not hold.[12] Consider the following extensive form game, adapted from the seminal contribution by Baron and Ferejohn (1989). N voters, $i = 1,\ldots,N$, must decide in how to split a cake; the se of possible divisions of the cake is given by $X = \{x_1,\ldots,x_N\}$, with $x_i \geqslant 0$ for $i = 1,\ldots,N$ and $\sum_i x_i \leqslant 1$. Time runs from $t = 1$ to infinity; every period a voter, chosen at random with equal probabilities, is recognized to propose a cake division, which is subsequently put to a vote. If the cake division 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 discount the future according to a common factor δ. Baron and Ferejohn (1989) study stationary subgame perfect (SSP) Nash equilibria of this game, and this is the equilibrium prediction that has guided the related literature.[13]

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 with a bare major-

[11] See the one voter environment of Dasgupta and Williams (1995) as an attempt in this direction.

[12] 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.

[13] 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.

ity, enough for approval, and the proposer typically gets a larger share. The share demanded by the proposer, however, is typically smaller than predicted by equilibrium (Palfrey, 2015). A possible explanation is the considerable uncertainty faced by the proposer about the motivations of potential coalition partners. This invites for the consideration in the lab of communication between participants, which is in fact a feature of realistic bargaining situations. Agranov and Tergiman (2014) compare a treatment with rounds of free talk before a proposal is introduced with a treatment without communication in a lab implementation with $N = 5$ and $\delta = 0.8$. In both treatments, the first proposal is accepted with very high probability; however, in the free talk 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.

Baranski and Kagel (2015) consider rounds of free talk 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 with public communication (open door), which somewhat reduces the power of the proposer.

7 Final remarks

References

Agranov, M., Goeree, J., Romero, J., Yariv, L., 2017. What makes voters turn out: The effects of polls and beliefs. Journal of the European Economic Association forthcoming.

Agranov, M., Tergiman, C., 2014. Communication in multilateral bargaining. Journal of Public Economics 118, 75–85.

Ali, N., Goeree, J., Kartik, N., Palfrey, T., 2008. Information aggregation in standing and ad hoc committees. American Economic Review: Papers & Proceedings 98 (2), 181–186.

Andreoni, J., Rao, J., 2011. The power of asking: How communication affects

selfishness, empathy, and altruism. Journal of Public Economics 95 (7), 513–520.

Austen-Smith, D., Banks, J., 1996. Information aggregation, rationality, and the Condorcet jury theorem. American Political Science Review 90 (1), 34–45.

Baranski, A., Kagel, J., 2015. Communication in legislative bargaining. Journal of the Economic Science Association 1 (1), 59–71.

Baron, D., Ferejohn, J., 1989. Bargaining in legislatures. American Political Science Review 83 (4), 1181–1206.

Barro, R., 1973. The control of politicians: An economic model. Public Choice 14, 19–42.

Battaglini, M., Morton, R., Palfrey, T., 2007. Efficiency, equity, and timing of voting mechanisms. American Political Science Review 101 (3), 409–424.

Battaglini, M., Morton, R., Palfrey, T., 2008. Information aggregation and strategic abstention in large laboratory elections. American Economic Review: Papers & Proceedings 98 (2), 194–200.

Bhattacharya, S., Duffy, J., Kim, S., 2017. Voting with endogenous information acquisition: Experimental evidence. Games and Economic Behavior 102, 316–338.

Bolton, G. E., Chatterjee, K., McGinn, K., 2003. How communication links influence coalition bargaining: a laboratory investigation. Management Science 49 (5), 583–598.

Borda, J., 1784. Mémoires sur les élections au Scrutin. Paris: Histoire de l'Academie Royale des Sciences.

Bornstein, G., 1992. The free-rider problem in intergroup conflicts over step-level and continuous public goods. Journal of Personality and Social Psychology 62 (4), 597–606.

Bouton, L., Castanheira, M., Llorente-Saguer, A., 2017. Multicandidate elections: Aggregate uncertainty in the laboratory. Games and Economic Behavior 101, 132–150.

Callander, S., 2008. Majority rule when voters like to win. Games and Economic Behavior 64, 393–420.

Condorcet, M. J., 1785. Essai sur l'application de l'analyse à la probabilité des decisions rendues à la pluralité des voix. Imprimerie Royale.

Dasgupta, S., Williams, K., 1995. Search behavior of asymmetrically informed voters: an experimental study. Economics & Politics 7 (1), 21–41.

Dasgupta, S., Williams, K., 2002. A principal-agent model of elections with novice incumbents: Some experimental results. Journal of Theoretical Politics 14 (4), 409–438.

Downs, A., 1957. An Economic Theory of Democracy. New York: Harper and Row.

Duggan, J., Martinelli, C., 2017. The political economy of dynamic elections: Accountability, commitment, and responsiveness. Journal of Economic Literature 55 (3).

Duverger, M., 1954. Political Parties: Their Organization and Activity in the Modern State. New York: Wiley.

Elbittar, A., Gomberg, A., Martinelli, C., Palfrey, T. R., 2016. Ignorance and bias in collective decisions. Journal of Economic Behavior & Organization.

Endersby, J. W., 1993. Rules of method and rules of conduct: An experimental study on two types of procedure and committee behavior. Journal of Politics 55 (1), 218–236.

Esponda, I., Vespa, E., 2014. Hypothetical thinking and information extraction in the laboratory. American Economic Journal: Microeconomics 6 (4), 180–202.

Feddersen, T., Pesendorfer, W., 1996. The swing voter's curse. American Economic Review 86 (3), 408–204.

Feddersen, T., Pesendorfer, W., 1997. Voting behavior and information aggregation in elections with private information. Econometrica 65 (5), 1029–1058.

Feddersen, T., Pesendorfer, W., 1998. Convicting the innocent: The inferiority of unanimous jury verdicts under strategic voting. American Political Science Review 92, 23–36.

Ferejohn, J., 1986. Incumbent performance and electoral control. Public Choice 50 (5-25).

Fey, M., 1997. Stability and coordination in Duverger's law: a formal model of pre-election polls and strategic voting. American Political Science Review 91 (1), 135–147.

Forsythe, R., Myerson, R., Rietz, T., Weber, R., 1993. An experiment on coordination in multi-candidate elections: The importance of polls and election histories. Social Choice and Welfare 10 (3), 223–247.

Forsythe, R., Rietz, T., Myerson, R., Weber, R., 1996. An experimental study of voting rules and polls in three-candidate elections. International Journal of Game Theory 25 (3), 355–383.

Fudenberg, D., Levine, D. K., 1993. Self-confirming equilibrium. Econometrica 61 (3), 523–545.

Gerber, E., Morton, R., Rietz, T., 1998. Minority representation in multimember districts. American Political Science Review 92 (1), 127–144.

Goeree, J., Yariv, L., 2011. An experimental study of collective deliberation. Econometrica 79 (3), 893–921.

Goeree, J., Yariv, L., 2015. Conformity in the lab. Journal of the Economic Science Association 1 (1), 15–28.

Großer, J., Schram, A., 2006. Neighborhood information exchange and voter participation: An experimental study. American Political Science Review 100 (2), 235–248.

Großer, J., Schram, A., 2010. Public opinion polls, voter turnout, and welfare: An experimental study. American Journal of Political Science 54 (3), 700–717.

Großer, J., Seebauer, M., 2016. The curse of uninformed voting: An experimental study. Games and Economic Behavior 97, 205–226.

Guarnaschelli, S., McKelvey, R., Palfrey, T., 2000. An experimental study of jury decision rules. American Political Science Review 94 (2), 407–423.

Houser, D., Morton, R., Stratmann, T., 2011. Turned on or turned out? Campaign advertising, information and voting. European Journal of Political Economy 27 (4), 708–727.

Houser, D., Stratmann, T., 2008. Selling favors in the lab: experiments on campaign reform. Public Choice 136 (215-239).

Hung, A., Plott, C., 2000. Information cascades: Replication and an extension to majority rule and conformity-rewarding institutions. American Economic Review 91 (5), 1508–1520.

Kittel, B., Luhan, W., Morton, R., 2014. Communication and voting in multi-party elections: An experimental study. The Economic Journal 124 (574).

Klor, E., Winter, E., 2007. The welfare effects of public opinion polls. International Journal of Game Theory 35, 379–394.

Klor, E., Winter, E., 2014. On public opinion polls and voters' turnout, The Hebrew University of Jerusalem, unpublished.

Levine, D. K., Palfrey, T., 2007. The paradox of voter participation? A laboratory study. American Political Science Review 101 (1), 143–158.

Lupia, A., 1994. The effect of information on voting behavior and electoral outcomes: An experimental study of direct legislation. Public Choice 78 (1), 65–86.

Martinelli, C., 2006. Would rational voters acquire costly information? Journal of Economic Theory 129 (1), 225–251.

Martinelli, C., 2007. Rational ignorance and voting behavior. International Journal of Game Theory 35 (3), 315–335.

McKelvey, R. D., Ordeshook, P. C., 1984a. An experimental study of the effects of procedural rules on committee behavior. Journal of Politics 46 (1), 182–205.

McKelvey, R. D., Ordeshook, P. C., 1984b. Rational expectations in elections: Some experimental results based on a multidimensional model. Public Choice 44 (1), 61–102.

McKelvey, R. D., Ordeshook, P. C., 1985a. Elections with limited information: A fulfilled expectations model using contemporaneous poll and endorsement data as information sources. Journal of Economic Theory 36 (1), 55–85.

McKelvey, R. D., Ordeshook, P. C., 1985b. Sequential elections with limited information. American Journal of Political Science, 480–512.

McKelvey, R. D., Ordeshook, P. C., 1987. Elections with limited information: A multidimensional model. Mathematical Social Sciences 14 (1), 77–99.

McKelvey, R. D., Ordeshook, P. C., 1990. Information and elections: Retrospective voting and rational expectations. In: Ferejohn, J. and Kuklinski, J. (Ed.),

Information and Democratic Processes. University of Illinois Press Champaign, pp. 281–312.

McKelvey, R. D., Palfrey, T., 1995. Quantal response equilibria for normal form games. Games and Economic Behavior 10 (1), 6–38.

Morton, R., Williams, K., 1999. Information asymmetries and simultaneous versus sequential voting. American Political Science Review 93, 51–67.

Myerson, R., 1998. Population uncertainty and Poisson games. International Journal of Game Theory 27 (3), 375–392.

Myerson, R., Weber, R., 1993. A theory of voting equilibria. American Political Science Review 87 (1), 102–114.

Palfrey, T., 1989. A mathematical proof of Duverger's law. In: Ordeshook, P. (Ed.), Models of Strategic Choice in Politics. Ann Arbor: University of Michigan Press.

Palfrey, T., 2015. Experiments in political economy. In: Kagel, J. H., Roth, A. E. (Eds.), Handbook of Experimental Economics. Vol. 2.

Palfrey, T., Rosenthal, H., 1983. A strategic calculus of voting. Public Choice 41 (1), 7–53.

Palfrey, T., Rosenthal, H., 1985. Voter participation and strategic uncertainty. American Political Science Review 79 (1), 62–78.

Palfrey, T., Rosenthal, H., 1991. Testing game-theoretic models of free riding: new evidence on probability bias and learning. In: Palfrey, T. (Ed.), Laboratory Research in Political Economy. University of Michigan Press, Ann Arbor.

Palfrey, T., Rosenthal, H., Roy, N., 2017. How cheap talk enhances efficiency in threshold public goods games. Games and Economic Behavior 101, 234–259.

Plott, C., 1991. A comparative analysis of direct democracy, two-candidate elections, and three-candidate elections in an experimental environment. In: Palfrey, T. (Ed.), Laboratory Research in Political Economy. University of Michigan Press, Ann Arbor.

Reitz, T., Myerson, R., Weber, R., 1998. Campaign finance levels as coordinating signals in three-way, experimental elections. Economics & Politics 10 (3), 185–218.

Riker, W., Ordeshook, P., 1968. A theory of the calculus of voting. American Political Science Review 62 (1), 25–42.

Riker, W. H., 1982. The two-party system and Duverger's law: An essay on the history of political science. American Political Science Review 76 (4), 753–766.

Riker, W. H., Zavoina, W. J., 1970. Rational behavior in politics: Evidence from a three person game. American Political Science Review 64 (1), 48–60.

Roth, A. E., Erev, I., 1995. Learning in extensive-form games: Experimental data and simple dynamic models in the intermediate term. Games and Economic Behavior 8 (1), 164–212.

Schram, A., Sonnemans, J., 1996. Why people vote: Experimental evidence. Journal of Economic Psychology 17, 417–442.

Tullock, G., 1967. Towards a Mathematics of Politics. University of Michigan Press.

Tyszler, M., Schram, A., 2011. Information and strategic voting. Tinbergen Institute Discussion Paper.

Tyszler, M., Schram, A., 2013. Strategic voting in heterogeneous electorates: An experimental study. Games 4 (4), 624–647.