

From Uninformed to Informed Choices: Voters, Pre-Election Polls and Updating

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June 17, 2009

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1 Abstract

Pre-election opinion poll results for U.S. presidential contests have large variation in the early parts of the primary campaigns, yet pre-election opinion polls later in the campaign are typically within several percentage points of the actual outcome of the contest in November. This paper argues this convergence process is consistent with boundedly rational voters making decisions with low information by examining the process by which voters can use opinion polls to guide their candidate choice. We undertake a series of laboratory experiments where uninformed voters choose between two candidates after participating in a series of pre-election polls. We demonstrate that voters update their beliefs about candidate locations using information contained in the opinion polls. We compare two behavioral models for the updating process and find significant evidence to support a boundedly rational Bayesian updating assumption. This assumption about the updating process is key to many theoretical results which argue that voters have the potential to aggregate information via a coordination signal and for their beliefs to converge to the true state of the world. This finding also indicates that uninformed voters are able to use pre-election polls to help them make their decisions.

2 Introduction

There is extensive research on American voters to indicate a large proportion of voters do not know a great deal about politics.¹ Yet while voters may not have the incentives to pay the costs associated with becoming informed (as the probability that they cast a pivotal vote is extremely low), this does not imply that they vote randomly (Wittman 1989). Voters may use other processes to obtain information, such as reliance upon a trusted peer or reliance upon an interest group (Downs 1957, Lupia and McCubbins 1998). As stated by Popkin *et al* “an individual facing a choice situation like voting, where the number of alternatives is limited, need only gather enough information to determine which alternative is preferable” (pg 789, 1976). Institutions which assist voters in their decision can both allow voters to remain uninformed about politics, consistent with the literature on voter informedness, as well as to cast votes as if they had full information.

This paper examines the role pre-election polls play in helping uninformed voters procure information. If institutions such as pre-election polls are useful to inform voters about which candidate to select without the voter ever knowing a significant amount of information about the candidates, then in fact the uninformed voters are likely to choose the candidates who best represent their interests without knowing a great deal about politics (McKelvey and Ordeshook 1986, McKelvey and Ordeshook 1985b). Pre-election polls are an institution which affect outcomes by providing additional information (Ordeshook and Palfrey 1988) and one particular advantage of such an instrument is that pre-election polls are available to all voters quickly and easily in all sorts of public media. The extent to which uninformed voters may use this information may assist in producing a more representative democracy.

Political scientists have long empirically debated the role of pre-election polls in elec-

¹Voters may not know the number of senators from their state, for example, and less surprisingly may have difficulty locating themselves and the candidates on ideological spectrum, remembering the names of candidates, or knowing where any particular candidate stands on a broad set of issues (Almond and Verba 1963; Berelson, Lazarsfeld and McPhee 1954; Campbell, Converse, Miller and Stokes 1960; Converse 1964; Kinder and Sears 1985).

tions (Perse 2001). Many scholars have found bandwagon effects, where individuals are thought to be more likely to support the candidate who is receiving majority support (Marsh 1984, Mutz 1998, Nadeau et al. 1993, Goidel and Shields 1994, Lazarsfeld, Berelson and Gaudet 1968). Other scholars have found support for the underdog effect, where individuals are thought to be more likely to support the candidate who is not receiving majority support (Cici and Kain 1982, Mehrabian 1998, Tannenbaum 1986). A few studies have found evidence of both (McAllister and Studlar 1991). Other research has argued that in fact voters become enlightened in the course of the campaign (Gelman and King 1993). This literature is unable to specify a mechanism by which voters use the pre-election polls, in large part because the data surrounding these polls and the events of the natural world are noisy, which makes it difficult to adjudicate between theories.

This paper uses a laboratory experiment to analyze the micro-foundations of how individual voters are able to rely upon pre-election polls for information. Understanding this mechanism provides leverage to adjudicate between theories. For example, if voters are indeed able to use the outcomes of the pre-election polls for information, then it is possible test if voter behavior is consistent with both the underlying mechanism and the bandwagon effect. In the laboratory setting, pre-election polls appear to be an effective public coordinating signal that results in "correct" voting even when the voters are relatively uninformed about the candidate platform positions (McKelvey and Ordeshook 1985b, 1986, 1990, Plott 1991, Forsythe, Myerson, Rietz and Weber 1993, 1996). This paper unravels the underlying mechanism by which voters are able to use these pre-election polls to inform their vote choices by isolating this behavior in the laboratory. In particular, we are interested in the mechanism by which voters will update their beliefs after observing a series of pre-election polls. Through our laboratory experiments we test the assumption that voters will update their beliefs using a boundedly rational Bayesian updating process. If voters are indeed updating their beliefs in this particular way, validating this assumption has implications for other positive political theory models which rely upon this assumption for convergence of voter beliefs. This also demonstrates the way in

which polls can be used to guide voter decision-making.

We are particularly interested in the process by which voters update their beliefs. We test the assumption from earlier work on pre-election polls where voters updating is assumed to be part of a Markov process (McKelvey and Ordeshook 1984, 1986). By identifying the belief updating process that enables voters use information in pre-election polls, we can evaluate to what extent the polls enable them to make more informed choices. Theoretically, boundedly rational voters update their beliefs based on these polls. However, the updating process is not costless in terms of cognition, therefore simply because it is theoretically possible for voters to use this information to make good choices does not necessarily mean that they will.

We compare two behavioral hypotheses for how voters will cast their ballots – one in which they base their vote upon a heuristic rule and do not update, and one in which they use a boundedly rational method of Bayesian updating. We test these behavioral hypotheses against each other and against the pattern of votes that would have been cast as if the voters were fully informed. The boundedly rational Bayesian updating explains the greatest number of votes in the experiment. This indicates that voters are able to use the pre-election polls as an information source in order to accurately cast their ballot.

3 Departures from McKelvey and Ordeshook (1985): Beliefs and Convergence

Our empirical test of the voter belief formation process is located within the theoretical literature on pre-election polls. We design our experiment based upon the formal model described in the McKelvey and Ordeshook (1985) paper titled "Elections with Limited Information". McKelvey and Ordeshook (1985) show that by giving a set uninformed voters no more than a prior on the partisanship of two candidates and their location in the distribution of voters (which includes some informed voters), there exists a unique equilibrium where the voting strategies of the uninformed voters in conjunction with a series of pre-election poll results (that include the votes of informed voters), reveal the candi-

date midpoint to the uninformed voters and allow them to cast their ballots as though they had perfect information. Because we are focused on a test of the formation of uninformed voter beliefs, we design our experiment consistent with this model for several reasons. First, in this strategic game the uninformed voters equilibrium strategies are identical whether they are sincerely or strategically voting. Thus in our experiment, the unique equilibrium strategy is for the voters to cast a ballot for the candidate they most prefer. This means that we do not have to be concerned with a test of whether or not the voters are casting votes strategically and are able to instead discern to what extent the voters are updating their beliefs. Second, this model allows us to highlight the implications of the updating process. Voters who update their beliefs are able, with minimal knowledge at the beginning of an election cycle, to cast votes as though they knew the true candidate locations.

In the McKelvey and Ordeshook formal model the players are either one of the N voters (informed and uninformed) or one of two candidates, A and B. Voters have two pure strategies: to cast a vote for A or to cast a vote for B. Abstention is not allowed. Candidates' choose a platform position on the unit interval. An equilibrium to the game is a vector of strategies and beliefs where each voter votes for the candidate whose ideal point is on the same side of the candidate midpoint as the voter's ideal point, where each candidate chooses a platform position to maximize her payoff based upon her beliefs about the median informed voter, and where uninformed voters know the true candidate midpoint and uninformed voters use the pre-election poll data as a measurement of the candidate midpoint. The updating process is described where

"uninformed voters initially vote randomly. After observing the first poll, they obtain an estimate of the candidate midpoint on the basis of that poll, assuming that other voters except themselves are informed. This leads to a new poll result. Uninformed voters revise their beliefs based on this new poll. It can be shown that this process converges to the equilibrium"

(McKelvey and Ordeshook 1990, pg 306). McKelvey and Ordeshook then attempt to ver-

ify this claim experimentally, but their experimental setup, which assign subjects to be informed voters, uninformed voters, and candidates, creates two problems.² First, since the candidates are subjects and are rewarded for winning the election, they consistently choose their platform positions at the voter midpoint, thus it is not possible to observe a convergence process. Voters anticipate this choice of platform position, and also voting choices based upon this platform position are identical to both those of updating and a heuristic approach. Second, given that some subjects are informed voters, the subjects who are assigned to be uninformed voters will know that the pre-election poll results will be noisy and this prevents us from being able to isolate the updating process.

We modify the experimental setup of McKelvey and Ordeshook (1985) to enable us to test whether or not indeed the uninformed voters are able to have beliefs which converge to the true candidate midpoint after a series of polls. First, we extend the number of polls. McKelvey and Ordeshook conduct only two pre-election polls and then an election in a total of two experimental sessions. We anticipate that by doing so we will be able to in fact observe convergence. Second, we control the informed voters and candidates. This reduces the amount of noise in the experimental setup and allows us to focus more specifically upon the uninformed voters. Finally, we move the candidate midpoint around the one-dimensional space. Because the McKelvey and Ordeshook framework permitted the subjects to be candidates (and in equilibrium the candidates will locate at the median voter), there is very little variation in candidate position across elections. We anticipate that by moving the candidate midpoint we will be able to determine to what extent we observe convergence within each election, and not be concerned about voters realizing the candidate strategies of locating at the median voter across elections.

Our experimental test will allow us to validate the mechanism which drives the McK-

²In their experimental setup, voters have symmetric single-peaked preferences, and the distribution of preferences of the electorate is publicly known. Candidates do not know which voters are informed or uninformed, hence they cannot target only the informed voters, but instead base their strategies upon the pre-election poll data. McKelvey and Ordeshook provide the candidate locations to the informed voters but permit the uninformed voters to know the relative candidate location as a proxy for an indirect cue or historical fact, such as an endorsement or a party label.

elvey and Ordeshook model, where pre-election polls combined with a particular assumption about voter behavior result in beliefs that converge to the candidate midpoint. This claim is based upon a particular assumption about beliefs of uninformed voters— that voters will rely upon the decisions of others to update their own, but in particular will not recall the pattern of voters that have happened earlier. This is an unusual assumption given the literature on herding and cascades (Goeree et al. 2004, Goeree, Palfrey and Rogers 2003), where individuals do observe a string of decisions and do update their beliefs based upon that pattern. Here we do not test whether voters will aggregate their information consistent with an information cascade, as this is not the assumption which is made in the McKelvey and Ordeshook framework. Instead, we test whether or not there is evidence that voters use simply the most recent poll to update their decisions.

One of these key assumptions is how voters update their beliefs – they do so using Bayes Rule in a boundedly rational framework. To interpret the poll result and update their beliefs, each uninformed voter assumes that all other voters are fully informed and rational. This allows each voter to update beliefs about the candidate midpoint in each pre-election poll. However, the presence of uninformed voters will likely generate variance in the poll results, requiring revision of beliefs each period, which indicates that in fact not all voters are fully informed. The boundedly rational component of their belief formation is that voters are essentially memoryless with respect to the variance in the polls. Our goal will be to test whether or not this assumption is valid by inferring beliefs through the pattern of votes cast.

Understanding the mechanism by which voters update beliefs – an understanding, for example, that voters are in fact engaged in applying Bayes Rule to an observation made in the previous period of play – is key to determining that voters are in fact engaged in an updating process. In particular, understanding the mechanism by which voters update their beliefs the the potential to provide insights into the types of institutions which can generate information aggregation. Other research has documented various types of generalized information aggregation tools (Plott and Sunder 1988, Plott 2000, Roust and

Plott 2006, Barner, Feri and Plott 2005, Healy et al 2009) ; this note hopes to add to that literature by unraveling a particular assumption about individual beliefs during those processes. The assumption that the updating occurs in this way is found in other positive political theory models of political behavior on persuasion and social learning (DeMarzo, Vayanos and Zwiebel 2003, Ellison and Fudenberg 1995). This assumption is particularly tractable in positive political science models as it allows beliefs to follow a Markov chain process. Verifying the assumption that voters will indeed use a naive decision rule will assist in the fundamental understanding of the mechanisms behind the information aggregation processes. This will also provide a particularly tractable assumption for those engaged in positive political theory research.

We conduct our experiments with the anticipation that it will be possible for the uninformed voters to glean some information from the pre-election polls. However, there are often ways the observation of a public signal can prevent individuals from converging towards beliefs and actions based upon the true state the world (Feddersen and Pesendorfer 1996, Hung and Plott 1999). We anticipate that as the voters here have no incentive to cast a ballot for anything other than their sincere preference this public signal will work to reveal the true state of the world for all participants if indeed voters are updating their beliefs as described by McKelvey and Ordeshook (1986).

4 Experimental Setup

In this experiment all subjects are uninformed voters. Each voter is characterized by an ideal point on an integer within the interval $[0, 100]$ that was drawn from a uniform distribution. Uninformed voters do not know the platform location of either candidate A or B. We plot the histogram of uninformed ideal points in Figure 1. We drew the ideal points only once at the start of the experiment – the variance in their frequency relates to the variation in the number of subjects in each experimental session. The number of uninformed voters in each session varied based upon subject availability. For each session we had between 10 and 17 subjects as uninformed voters.

Figure 1 Goes Here

There were ten informed, computer-based “voters” in each treatment, whose ideal points were drawn from a uniform distribution over the integers from 0 to 100. This resulted in a realized set of ideal points for ten informed voters who are located on the integers (32,43,48,52,55,60,64,70,80,82) in sessions one and two and with ideal points (3,4,5,38,47,52,67,69,81,100) in sessions three, four and five.

Each uninformed voter has some small amount of information. The uninformed voter knows the relative locations of the candidate platforms – that is, which candidate’s platform is located further to the left. The uninformed voter knows the percentage of all voter (both uninformed and informed) ideal points to the left and to the right of her own ideal point. The uninformed voter also knows the total number of voters and the precise number of each type.

Each subject votes in a fixed number of pre-election polls where they are asked to reveal which candidate they most prefer if the election were held today. We incorporate the informed, computer-based “voters” choices into the results and present the total poll results for all the uninformed voters. That is, the uninformed voters observe a result after each poll which reads “X% for A, Y% for B”. This process repeats until the election, at which point the final results are announced and one candidate is declared the winner.

The candidates and the informed voters are completely controlled by the experimenter. There are two candidates (A and B) with platform positions located on an integer within the interval $[0, 100]$. Candidate A will always have a policy platform that is located to the left of candidate B. The candidate platform locations are determined by a random draw from a uniform distribution on the interval. The informed, computer-based “voters” vote sincerely and know both candidate locations.

The experiment begins with all uninformed voters asked to participate in a pre-election poll. Every voter must participate and vote for either candidate A or B. No voter may abstain. The voters are asked to vote in the poll as they intend to vote in the final election. After each poll, the results are publicly announced. These results include the votes

of both the uninformed and informed voters. The last poll is considered the election – voters' payoffs are primarily determined by this vote – and after the election results are announced, the candidate locations are revealed. The process then repeats with new candidate locations.

The experiment consists of two possible lengths – one in which there are three pre-election polls and then 1 election, and the second in which there are five pre-election polls and 1 election. Payoffs to the voters are determined by the distance between the winner of the election and their ideal point. In the longer experiment, a small bonus is given for correct voting in the pre-election polls. In the first length of experiment there are 12 total elections and in the second length of treatment there are 24 total elections.

Voters are assumed to vote sincerely, as any strategy that was not a sincere vote would be dominated by a sincere vote in equilibrium. This logic is explored in greater depth in McKelvey and Ordeshook (1986) and in Forsythe, Myerson, Rietz and Weber (1993) but can be summarized here in the case where a small bonus is given for correct voting in the pre-election polls. Suppose the voter were to cast a vote for her least-preferred candidate in the poll. She would then forfeit the benefit from having voted "correctly". If she believed that the other voters were not using the vote totals to update their beliefs, she would have no reason to forfeit this payment and would vote sincerely. If she believed that the other voters were using the vote totals to update their beliefs, then if she believed that they were updating their beliefs about the candidate location and assuming sincere voting, then she would vote sincerely as this would increase the probability that her most-preferred candidate would win the election, and thus increase her payoff. The only case where she would be willing to forfeit the payment would be if she believed that other voters were using the polls as a signal to indicate support for the opposite candidate and that by casting an opposite vote, she would be the pivotal vote in determining that her most-preferred candidate would win the election. The equilibrium with insincere voting would be Pareto dominated by the sincere-voting equilibrium because it would require sacrificing the bonus payment.

5 Data and Results

We conducted five experimental sessions in total. Three sessions consist of three polls and an election, and two sessions consist of five polls and an election. We have between ten and seventeen participants in each session, all of whom assume the role of uninformed voter. The sessions are described in Table 1. The entire set of experiments produces a total of 5,136 instances where an uninformed voter is asked to “cast a ballot” in either a poll or election. Each observation describes the behavior of one voter in one particular poll in one election in one session.

Table 1 Goes Here

Candidate ideal points are drawn from a uniform distribution, and the frequency of the candidate midpoint, the average of the two candidate ideal points, can be observed in Figure 2. We expect that the uninformed voters will rely upon the candidate midpoint that is expressed in the polls to make their decision. By changing the location of the candidate midpoint in each election we are able to examine the process of belief formation by generating two critical tests of our hypotheses: instances where the Bayesian updating rule produces different outcomes than a simple heuristic and looking for effects of variation in the difficulty of the information aggregation, which should only effect voters who are updating. While the true candidate midpoint ranges from 8.5 to 96.5 (with a mean of 54.29), the observed candidate midpoint in the polls, which the uninformed voters observe as a proxy for the true candidate midpoint to produce their beliefs about the candidate ideal points, ranges from 20 to 90 (with a mean of 52.87). Note again that the voters’ ideal points are drawn from a uniform distribution, with the uninformed voters having ideal points which range from 2 to 99 (with a mean of 46.45). Across all polls and elections, the uninformed voters cast a total of 2762 votes for candidate A and 2373 votes for candidate B.

Figure 2 Goes Here

We observe, for each session, the uninformed voter's decision in each poll and election. We also record the candidate midpoint and the publicly observed outcome of each poll and election. We anticipate that the outcome of the pre-election polls will be used by the uninformed voter to determine her beliefs about the candidate locations. We observe the length of the session, the number of uninformed voters in the session, and the particular poll number for that vote.

We have two distinct models of voting behavior which we hope to test with this experiment. First, we consider a model where the voter casts a vote based upon whether or not the voter is to the left or the right of the point 50. This corresponds to the belief that the expected candidate midpoint is at the point 50, given the random draw of candidate ideal points. We anticipate that if the voters do not use the pre-election polls to update their beliefs that they are likely to base their vote on this heuristic rule. Second, we consider a model based upon the boundedly rational Bayesian updating described by the McKelvey and Ordeshook (1986) assumption about the formation of voter beliefs – that the voters will form their belief about the candidate locations from only the previous pre-election poll result. This model indicates that the voter's decision will be based upon whether or not the voter is to the left or the right of the observed candidate midpoint for each poll. In the first poll, this model corresponds to the heuristic model.

We also consider whether or not the voter is to the left or right of the true candidate midpoint. This enables us to evaluate errors made by the voter given their limited information – we can compare how they would have voted with perfect information versus the models described above.

Based upon these models, we produce three indicators for when the voter's decision does not correspond with the vote predicted by each of these models. First, we produce an indicator variable which describes whether or not the voter cast her ballot in the poll or election for the candidate that was indeed the closest to her ideal point (and thus would yield her the greatest payoff). We will refer to this indicator as the "Correct Model" indicator. Next, we produce an indicator variable which describes whether or not the voter cast

her ballot for the candidate who would be, in expectation, on the same side of the point "50" as the voter herself. We refer to this indicator as the "Heuristic Model" indicator. Finally, we produce an indicator variable which describes whether or not the voter used, as though it were the absolute truth, the reported split from the previous poll. We refer to this indicator as the "Bayesian Model" indicator. We summarize each of observations that each of these models fails to correctly predict in Table 2.

Table 2 Goes Here

Table 2 describes the rate at which these failures-to-predict occur over the different polls. It is clear that the "Correct" model increases its predictive power over time, beginning at a rate of 12.59% for the first poll and ending with a rate of 4.37% for the last poll. Voters are in fact better able to discriminate between the two candidates after observing a series of polls. This is consistent with the existing literature which suggests that pre-election polls are an effective communication device as well as with the McKelvey and Ordeshook (1986) results that the voters should be converging to a set of common beliefs about the candidate midpoint.

It appears that the Bayesian indicators follow a similar pattern, where the model fails to predict 9.39% of the votes in the first poll but merely 3.17% of the votes in the last poll. For the remaining two polls – polls five and six – the Bayesian model is more effective at predicting behavior than assuming voters have the "correct" information, although this difference is not statistically significant at traditional levels. Note also that this model is able to predict, in total, all but 9.61% of all votes cast. This is the first set of evidence to indicate support for the boundedly rational Bayesian updating assumption – that not only is this model effective at predicting behavior, but that it is able to do so at rates similar to assuming that the voters have full information. In particular in the higher predictive power of the later polls suggests that the Bayesian model gains predictive power as the number of polls increase. The Heuristic indicator, however, appears to generate a fairly constant rate of failures-to-predict, beginning with 9.39% in the first poll and ending with 13.88% in the last poll.

This pattern can be seen more clearly in Figure 3. Note particularly that as the number of polls increases, the Bayesian Model is able to better predict behavior than even the "Correct Model".

Figure 3 Goes Here

We next look for evidence that voters are indeed using the Bayesian Model and compare the predictive power of this model to the Heuristic Model. We demonstrate that voters are incorporating the previous poll results into their decision and not voting based simply upon the candidate's expected positions and disregarding pre-election polls.

We begin by summarizing the raw data into a series of critical tests. We look at instances where one model predicts that all individuals will vote for one candidate but another predicts a vote for the opposite candidate. Thus, the first row in the table compares the instances where the Heuristic Model predicts a vote for candidate A but the Correct Voting Model predicts a vote for candidate B. In our data-set, there are 404 total observations where this is true, and of those observations, there are 212 votes cast for candidate A and 192 votes cast for candidate B. We perform the same calculation for when the Heuristic model predicts a vote for candidate B and the Correct Voting Model predicts a vote for candidate A. Here there are 724 observations where this is true, and of those observations there were 341 votes cast for candidate A and 383 votes cast for candidate B. Thus when we directly compare the critical tests – cases where the Heuristic Model and the Correct Voting Model had different theoretical predictions – we note that the Heuristic Model was able to correctly predict 49.02% of the votes and the Correct Voting Model was able to correctly predict 50.98% of the votes. These percentages are not different at statistically significant levels and thus we are not able to discern differences between Correct Voting and the Heuristic Model.

We are particularly interested in the next set of tests, however, Of the 615 observations where the Heuristic Model makes different theoretical predictions than the Bayesian Model, the Bayesian Model correctly predicts 412 votes. That is, the Heuristic model predicts only 33.05% of the votes and the Bayesian Model predicts 66.99% of the votes. Based

upon a t-test for a difference in means this is a statistically significant difference at the $\alpha = .01$ level. Thus we can conclude that the Bayesian Model is a much better predictor of behavior than the Heuristic Model.

The Bayesian Model also predicts better than Correct Voting, with 63.53% of the votes explained by the Bayesian Model and only 36.47% of the votes explained by Correct Voting. This is a statistically significant difference at the $\alpha = .01$ level. This is a particularly interesting finding, as it suggests that voters are indeed using the Bayesian Model as the process by which they are aggregating their information. Yet because they are relying upon the pre-election polls, it may be some time before the voters are able to converge upon the true candidate midpoint. In the cases where there is a discrepancy between the two, relying upon the information that voters can see is more effective than assuming they have been effective at aggregating the information in some other way that would allow them to choose their most-preferred candidate. This suggests that in fact voters are updating in correspondence to the Bayesian Model.

We also examine the instances when the models have the same predictions to understand what our base-rate of prediction is – and also to indicate that for many instances in our experiment, the three models predict the same outcomes. For all models we can predict just over 80% of the votes in all comparisons. We summarize these results in Table 3 and Table 4.

Table 3 and Table 4 Goes Here

We next pool all sessions together to evaluate the two distinct models in a regression context. Based upon the raw data presented in the prior tables, we anticipate that there will be significant support for the Bayesian Model and not for the Heuristic Model nor for Correct Voting. In the first regression, we produce indicators for whether or not each of these three models predicts a vote for candidate A. We then analyze the effect of each of these indicators on our dependent variable, which is an indicator for whether or not the voter cast a vote for candidate A. These coefficients are presented in Table 5.

Table 5 Goes Here

The first column indicates the coefficients when all three indicators are included. Here we notice that all three coefficients are positive and statistically significant and that their 95% confidence intervals include each other, thus making it impossible to discard any of the three.³ However, we do find that the Bayesian Model indicator coefficient is the largest. We try running separate regressions for each of these models and while the likelihood ratio test prevents us from rejecting any of the indicators, we do also find that the Bayesian Model correctly predicts the largest number of votes.

We conduct one additional regression in order to directly compare the Heuristic and Bayesian Models. We construct a dependent variable which is an indicator for when a voter has cast a ballot in "error" – that is, a ballot cast for a candidate different than whom the voter would prefer under full information. We look at instances where only the Bayesian Model would predict that error and construct an indicator for those instances, and do the same for the Heuristic Model. Into this regression we also construct an indicator for if this is the first "election" in the experimental session, acknowledging that subjects may better understand the experiment after the first election. We also include a variable for the total number of subjects in the experiment – this accounts for some additional variance and uncertainty in the experiment. Our coefficients are presented in Table 6.

Table 6 Goes Here

Here again we find that both the Bayesian indicator and the Heuristic indicator are positive and significant and that their 95% confidence intervals overlap, so that we cannot differentiate them as statistically significantly different. Yet also again the Bayesian indicator is larger than the Heuristic indicator, providing further suggestive evidence for the Bayesian Model. We also see a positive coefficient for the first election in each session and for the total number of subjects, both of which are consistent with our expectations.

³Additionally, these variables are highly correlated with each other, with correlations .56 (Correct and Heuristic), .72 (Correct and Bayesian) and .76 (Bayesian and Heuristic).

In this section, we have conducted three tests in order to both evaluate the amount of support for the Bayesian Model as well as to compare the Bayesian Model against two other models of behavior. When we look at instances of critical tests where the models predict different outcomes, we find clear support for the Bayesian Model. This is particularly strong evidence given that there is a large and statistically significant difference between the Bayesian Model and Correct Voting. Voters rely upon the candidate midpoint. We do not see the difference emerge between these models in either regression context, when we include all the observations in our data-set, although the coefficient for the Bayesian Model is still the largest but not statistically distinguishable from the coefficient for the other models. However, this may be in large part do to the fact that these variables are highly correlated with each other, as demonstrated by the large number of instances where the models predict the same outcomes.

6 Conclusion

This analysis demonstrates that uninformed voters do in fact glean information from pre-election polls. We observe that the number of "errors" associated with voting decreasing over time. The fact that information about candidate location can be determined with such a small number of polls and such a limited set of information suggests that despite the surveys which find extensive lack of information amongst voters, voters may in fact be choosing the candidates whose ideologies are closest to their own. We find strong support for the Bayesian Model and are able to conclude that voters are indeed updating their beliefs consistently with this assumption. We are only able to reject the idea that voters are using a heuristic voting rule from the critical tests comparisons, however, and are simply able to note that the Bayesian Model is more effective at predicting "wrong" voting than the heuristic, albeit not at a level that is statistically distinguishable. It is possible that voters use some combination of both.

We note the trend in the rate at which the Bayesian Model is increasingly able to predict the choices of voters as we increase the number of polls and believe that this may

simply be a feature of the experiment – that voters are not only learning the information of the informed voters, but are also establishing beliefs about the strategies of the other participants in the experiment. For example, we find that there are the highest number of failures in the first election in each experimental session. Participant performance improves in the experiment as more elections are conducted. More polls help aggregation.

The principle finding from this paper is to find support for the mechanism by which voters will update their beliefs given the presence of pre-election polls. Thus we are able to rely upon existing theoretical work to know that it is possible for voters to eventually cast ballots as though they were informed voters. This phenomena is particularly key for the implications of staged primaries throughout the United States during the presidential contests. While it is possible that voters may be uninformed about the candidates, a basic awareness of poll outcomes may enable them to cast a "correct vote". Yet this also risks exposing voters to potential poll biases, raising issues about the accuracy of information presented and the implications of public polls before elections. More broadly, the consistent ability of individuals to aggregate information in this experiment speaks to the fact that the property of aggregation is a general feature of human interaction, as opposed to an accident of the properties of the experimental environment. In particular if voters are able to use pre-election polls to inform their choice, then we may observe much higher rates of "informed voting" than is typically claimed by scholars who study the informedness of the American electorate. This paper has demonstrated that polls have the potential to play a key role in providing information to voters.

7 Works Cited

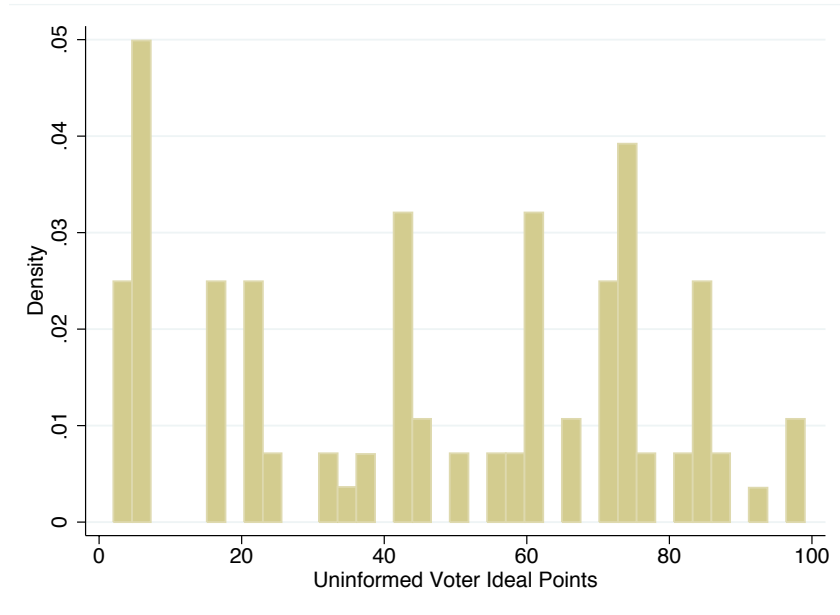
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8 Tables and Figures

Figure 1: Histogram of Uninformed Voter Ideal Points



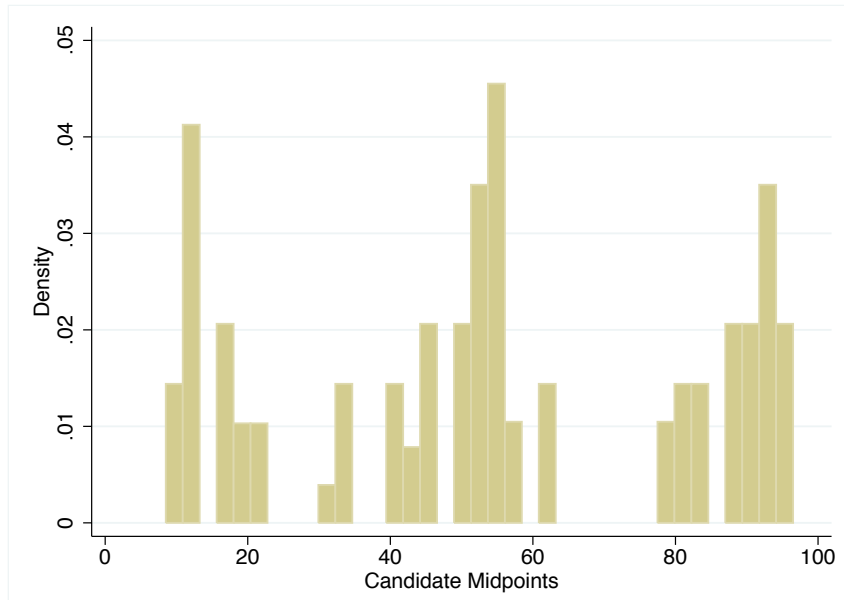
Note: This figure indicates the values randomly drawn from a uniform distribution by the experimenters for the uninformed candidate ideal points and their relative frequency in the experiment. The ideal points were drawn only once.

Table 1: Experimental Sessions

Session	Subjects (Uninformed Voters)	Length	Total Observations
One	17	3 Polls, 1 Election	816
Two	15	3 Polls, 1 Election	720
Three	12	3 Polls, 1 Election	576
Four	11	5 Polls, 1 Election	1584
Five	10	5 Polls, 1 Election	1440

Note: There were 10 informed voters in each experimental session, controlled by the experimenter. Sessions took place from November 2004-March 2005.

Figure 2: Histogram of Candidate Midpoints



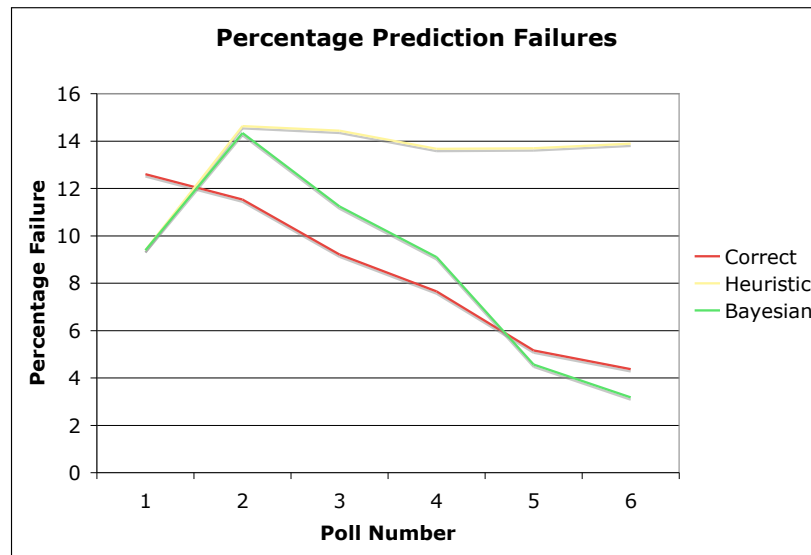
Note: This figure indicates the values chosen by the experimenters for the candidate midpoints and their relative frequency in the experiment.

Table 2: Percentage of Votes Each Model Fails to Correctly Predict

Model	Total	Poll 1	Poll 2	Poll 3	Poll 4	Poll 5	Poll 6
Correct	9.17% (471)	12.59%	11.53%	9.2%	7.65%	5.16%	4.37%
Heuristic	13.18% (677)	9.39%	14.63%	14.43%	13.66%	13.69%	13.88%
Bayesian	9.61% (494)	9.39%	14.34%	11.24%	9.1%	4.56%	3.17%
Total	5136	1032	1032	1032	1032	504	504

Note: The Bayesian Model assumes that beliefs are such that the candidate midpoint is located at 50 for Poll 1.

Figure 3: Percentage of Votes Each Model Fails to Correctly Predict



Note: The 95% confidence intervals are excluded from this figure but are available from the authors upon request. These intervals overlap for all three models.

Table 3: Critical Tests: Bayesian Model vs Heuristic Model vs Correct Voting

Model Predictions	First Model Votes	Second Model Votes	Total Obs	%First Model Predicts	% Second Model Predicts
Heuristic A & Correct B	212	192	404	52.47%	47.52%
Heuristic B & Correct A	341	383	724	47.10%	52.90%
Heuristic & Correct Different	553	585	1128	49.02%	50.98%
Heuristic A & Bayesian B	121	109	230	52.61%	47.39%
Heuristic B & Bayesian A	82	303	385	21.30%	78.70%
Heuristic & Bayesian Different	203	412	615	33.01%	66.99%
Bayesian A & Correct B	155	108	263	58.94%	41.06%
Bayesian B & Correct A	284	144	428	66.36%	33.64%
Bayesian & Correct Different	439	252	691	63.53%	36.47%

Table 4: Same Predictions: Bayesian Model, Heuristic Model and Correct Voting

	Votes	Total Obs	Percent Models Correctly Predict
Heuristic & Bayesian Predict Same A Vote	2007	2458	81.65%
Heuristic & Bayesian Predict Same B Vote	1731	2063	83.91%
Heuristic & Bayesian Same	3738	4521	82.68%
Heuristic & Correct Predict Same A Vote	1916	2284	83.89%
Heuristic & Correct Predict Same B Vote	1472	1724	85.38%
Heuristic & Correct Same	3388	4008	84.53%
Bayesian & Correct Predict Same A Vote	2155	2580	83.53%
Bayesian & Correct Predict Same B Vote	1556	1865	83.43%
Bayesian & Correct Same	3711	4445	83.49%

Table 5: Logit Coefficients: Model Comparisons, Vote for Candidate A

Dep. Var, Vote for Cand A	Coefficients			
Correct Voting (Predicts Vote for A)	1.08*	2.45*		
	(.091)	(.068)		
Bayesian Model (Predicts Vote for A)	1.55*		2.87*	
	(.112)		(.071)	
Heuristic Model (Predicts Vote for A)	.87*			2.38*
	(.096)			(.066)
Constant	-1.77*	-1.28*	-1.40*	-1.05*
	(.062)	(.052)	(.052)	(.046)
Pseudo R2	.321	.222	.292	.217
Percent Correctly Predicts	80.78%	76.73%	80.80%	77.16%
N	5136	5136	5136	5136
LR (Test Compares to Col. 1)		703.37	209.21	739.93
* $\alpha = .10$, * $\alpha = .05$				

Note: When comparing all columns to the first column via a likelihood ratio test we find that we cannot reject the null that all covariates are necessary.

Table 6: Logit Coefficients: Failure to Vote for Closest Candidate

Dep Var, Indicator for Voting "Error"	Coefficient
Crit. Indicator, Bayesian Model Predicts Failure (Correct & Heuristic Same)	.95* (.26)
Crit. Indicator, Heuristic Model Predicts Failure (Correct & Bayesian Same)	.61* (.14)
Total Number of Subjects	.16* (.02)
First Election in Session	.92* (.16)
Constant	-4.49* (.24)
**	$\alpha = .10$
*	$\alpha = .05$
N	5136

Note: The dependent variable here is an indicator for when the voter cast a ballot in favor of a candidate who would be different than her most-preferred if she had full information. The critical test indicators are defined as instances where the specified model predict these errors.

9 Appendix

These experimental sessions were all conducted using undergraduates enrolled at the California Institute of Technology. Subjects were paid in cash for their participation. Each session took approximately two hours. Below we have included the instructions each subject reads prior to the experiment.

9.1 Instructions

This experiment studies polling and voting in an election with two candidates. You will be paid for your participation on the basis of the decisions you make. If you are careful and make good decisions, you can make a substantial amount of money.

In this experiment, there are two candidates, labeled A and B, and you are a voter. You will participate in a number of periods, each consisting of three polls and an election.

In each period the candidates will take positions on a number line that goes from 0 to 100. Before each election three polls will be taken in which all voters are asked to indicate their preferred candidate. Then, the poll outcomes will be announced to the group. After the third poll, all voters will vote for a single candidate in the election and the candidate who gets the most votes will be considered the winner. At this point the candidates may move to new locations on the number line and the poll and election process will repeat.

Voters are paid for their participation on the basis of their payoff chart. Please turn to the last page of the instructions to view the sample payoff chart. Remember that this chart is a sample and not your true payoff chart. This chart depicts the line where candidates will take positions and a sample payoff for a voter. The line is simply the set of all numbers between 0 and 100. The experimenters will select candidate positions on the line for each period. Candidates are equally likely to be at the end of the line as they are to be at the middle of the line. Each voter will be paid based on the position of the winning candidate on her payoff chart. For example, suppose candidate A is located at position 20, candidate B is located at position 25, and candidate B wins the election. Then you would earn 400 francs for that period. Note that on the sample payoff the maximum payoff is at position 45.

Voters will also be paid on the basis of their polling choices. For each poll that the voter chooses the candidate that is closest to the voters maximum point, the voter will receive a small bonus in francs.

In the actual experiment, the payoff charts for each voter may be different. Each voter will have a payoff chart which has a maximum payoff. Payoffs decrease symmetrically as candidate positions move away from the maximum in either direction as in the sample chart. However, different voters maximums may be at different points on the number line, and their payoffs may decrease at different rates.

One important rule in the experiment is that the information on your payoff chart is private information. None of the other voters should know the information on your payoff chart. Please do not talk with other participants during the experiment. Are there any questions about the payoff chart?

In the experiment there will be two groups of voters (drawn from a uniform distribution) voting in each poll and election, uninformed and informed. All voters in this room are uninformed. This means that throughout each period the positions of the two candidates will not be made public. You will be given limited information about positions of the candidates and the other voters. Candidate A is always furthest to the left (closest to 0) and candidate B is always furthest to the right (closest to 100). You will also know, from your payoff chart, the percentage of all voters who have maximums to the left and to the right of your most preferred position.

The informed voters will be generated by the experimenters. The informed voters will know candidate positions and thus will always vote for their most preferred candidate. Every poll and election will include the true preferences of these voters. These voters are also included in the information you have about the percentage of voters who have maximums to the left and to the right of your most preferred position.

To review, the sequence of events will be as follows: At the start of each period the first poll will be taken and the results announced. Remember that both uninformed and informed voters will participate in all polls. The second and third polls will be taken and results announced. Then the final election will take

place. After the final election the candidate positions from that period will be announced. After the last period the experiment will end. At this point, voters will be paid the sum of their payoffs for the position of the winning candidate in each election. Your monetary payoffs are increasing in the number of francs you earn.

Please take a moment to fill out the quiz below using your true payoff chart and not the sample payoff.

Quiz:

1. My point of maximum payoff on my payoff chart is: (blank)
2. At this maximum point I will get a payoff of (blank) francs.
3. There are (blank) percent of voters to the left and (blank) percent of voters to the right of my maximum payoff point.
4. If Candidate A is at position 60, then Candidate B must be located between numbers (blank) and (blank).
5. True or False: By announcing the candidate that is closest to my maximum payoff in poll 1, I will get additional francs regardless of whether or not that candidate wins: (blank)

Are there any questions?

Figure 4: Sample Payoff

