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ORIGINAL ARTICLE

Candidate uncertainty, mental models, and complexity: Some experimental results

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Abstract Since the work of Downs (1957), spatial models of elections have been a mainstay of research in political science and public choice. Despite the plethora of theoretical and empirical research involving spatial models, researchers have not considered in great detail the complexity of the decision task that a candidate confronts. Two facets of a candidate's decision process are investigated here, using a set of laboratory experiments where subjects face a fixed incumbent in a two-dimensional policy space. First, we analyze the effect that the complexity of the electoral landscape has on the ability of the subject to defeat the incumbent. Second, we analyze the impact that a subject's "mental model" (which we infer from a pre-experiment questionnaire) has on her performance. The experimental results suggest that the complexity of a candidate's decision task and her perception of the task may be important factors in electoral competition.

Keywords Elections · Experiment · Incumbency · Spatial models · Complexity

> Boundedly rational parties may not be able to defeat incumbents. Mathematical proofs of the **existence** of winning strategies should not be equated with the **ability** of human actors or organizations to locate them. . . . The lack of information among voters has received a great deal of theoretical attention; the lack of information among parties and candidates deserves to be explored, as well. (Kollman, Miller, & Page, 1992, p. 936; emphasis added).

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Introduction

Over the past 20 years, scholars have recognized two significant problems with the "formal theory" of elections and campaigns. First, aggregate-level predictions contradict "real" election results. Policy is relatively stable, and incumbents usually win, *contra* the predictions of the unaugmented classical spatial model. Second, it is not clear which micro-level, or behavioral, data sets or observations would be appropriate to "test" spatial models. It is difficult to separate the myriad forces that directly or conditionally influence the choices and actions of political agents. What has become clear is that, as the passage from Kollman, Miller, and Page (1992) above asserts, uncertainty and the problems of complexity need to be addressed before any progress can be made.

None of this means that spatial models, or other formal models of human political behavior, are not testable. It just means that real world election data or surveys are contaminated by too many confounding factors to allow valid inference or discrimination among theories. This paper uses an experimental design to investigate the relationship between an approach to problem solving (which we will call "mental models") and the choices of human subjects in a setting where information is complete but complex. The specific context is a game where subjects are pitted against a static "incumbent" located in a 20×20 two-dimensional policy space, with the distribution of voters represented visually by numbers at each policy. The distributions from which voter densities were drawn were allowed to differ to achieve the key experimental manipulation (i.e., complexity).

It is useful to summarize the results presented in this paper to give the reader an idea of where we are headed before becoming immersed in the details. First, it is clear that the problem of spatial location for political candidates is a complex one. The fact that there is a feasible "best" choice by a challenger(s) does not mean that it will be found, even in a setting of complete information. Consequently, an important source of "incumbency" advantage may simply be selection, based on good luck or sophistication. In any case, the fact that challengers have a hard time beating a vulnerable incumbent under the highly simplified assumptions used here implies that some of the *ad hoc* "incumbency advantage" explanations in the literature may not be necessary to bolster the spatial model.

Second, the "mental model" that the subjects bring to the experiment matters significantly in explaining the pattern of results. The spatial location game with which subjects were presented clearly depends on both the configuration of voter preferences and the location of the "incumbent". But those subjects who, in a pre-test survey, listed voter preferences or opponent location as important performed better than average, while those who emphasized the candidate's own values and goals (irrelevant in this experiment, by construction) performed worse than average. More simply, subjects with inaccurate or inappropriate mental models appear to have applied a false analogy. Interestingly, they held to this analogy even though it hurt their performance, and reduced their monetary compensation in the experiment.

Finally, subjects learned. They showed improvement in average performance over the course of the 25 trials that made up each experimental session, as they were able to identify patterns and shortcuts of the complex location problem.

Incumbency, complexity, and mental models

> What does a House member see when looking at his or her constituency? Kaleidoscopic variety, no doubt. That is why there can be no one "correct" way of slicing up and classifying member perceptions. . .. When House members contemplate their districts,

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> some of them may not see the same demography that political scientists see. And herein lies an early warning that *more uncertainty may attend a congressman's perceptions of his constituency than students armed with census data and standing at a distance may have expected* (Fenno, 1978, p. 1–4; emphasis added).

In Home Style, Richard Fenno appeared to be doing an analysis of incumbents' "style" of representing and campaigning in their districts. Many portions of the book do, in fact, address just this subject. But many of the most interesting parts of *Home Style* are concerned with the problem of "perceptions" of the district. The language Fenno uses ("Kaleidoscopic variety", "no one 'correct' way of classifying") is deceptively simple. The point is that politicians, *all* politicians, have to solve an overwhelmingly, perhaps irreducibly, complex problem: What is the nature of my district?

Fenno's well chosen word, "perceptions", plays a significant role in his analysis. Candidates operate in a world of limited and expensive information, and each candidate must grapple with the problem of deciding how to allocate resources and make the "presentation of self" that voters use to form their impressions of the candidate. Fenno claims that successful incumbents have useful perceptions, or mental "summaries" of the nature of the district. It is hard to know how candidates might arrive at these simplified mental representations of the district, but the electoral process clearly selects for candidates whose perceptions are accurate and give good guides to campaign choices. There is obviously a similarity between this notion of "perceptions" or mental models and the literature in political psychology (Singer, 1968; Axelrod, 1973; Taylor & Crocker, 1981; Lau, 1989), and more recently in the rational choice literature (Denzau & North, 1994; Hinich & Munger, 1994; Lupia & McCubbins, 1998). One might think of these models as an assumption about the way the world works, a maintained conception of means-ends relationships. The process by which these mental models are formed is not well understood, and though some are clearly better than others, people may persist in using model, or "schema", even after its value seems questionable.

Fenno's method of intensive participant observation is well suited to the idea that candidate impressions are the driving force behind the choice of style. But then the question becomes one of generalizability: If candidate perceptions of the district drive behavior and those perceptions are unique products of time and personality, is it possible to analyze campaigns at all? The answer is yes, if one credits two claims. The first is the "survival test", which is consistent with the rational choice approach but much less restrictive in terms of the behavior it allows. The second is the claim that electorates are usefully characterized by their complexity, especially in terms of the homogeneity or heterogeneity of voters in that district.

Survival test: Complexity causes incumbents' advantage

Alchian (1950) characterizes the survival test in economics in terms of the process of selection and incentives, analogous to the process of natural selection in biological processes. Alchian pointed out that the explicit assumption that economic agents behave "optimally" (in the case of firms, maximizing profits) is not necessary to be able to make predictions about the pattern of agents that survive. In particular (in Alchian's words), when "foresight is uncertain, [optimization] is *meaningless* as a guide to specifiable action.... Uncertainty arises from at least two sources: imperfect foresight and human inability to solve complex problems containing a host of variables even when an optimum is definable" (p. 211–2; emphasis in original).

Incumbents, by definition, have already won at least one race in the district, and may therefore be advantaged if there is uncertainty, either because of imperfect foresight or because

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of the difficulty of solving complex problems. Even if all candidates initially choose positions randomly, the prior electoral test implies that *current* incumbents had platforms that were better than those of the other candidates. When it turns out that one candidate gets more votes than another, we cannot conclude an active or efficient agent was at work. But once a "good" position (in relative terms) is revealed by the fact that voters have selected a candidate, that incumbent simply continues to behave the same way. To summarize, in complex electoral settings, incumbents should have an advantage. The more complex the setting, the greater is the extent of this advantage.

Complexity

Fenno (1978, p. 4) notes that "[o]f all the internal characteristics of the district, the one that best illuminates subsequent member perceptions is district homogeneity or heterogeneity". One interpretation of Fenno's observation, of course, is the standard view in spatial theory: *Complex* disagreement (multiple dimensions, many separate factions) leads to *electoral vulnerability*. Agreement, or even *simple* disagreement (for example, diversity of opinion in one dimension, assuming preferences are single-peaked, so that the Median Voter Theorem can be applied) means that incumbents should be secure, assuming the initial selection process placed them at or near the optimal position.

And there is substantial experimental support for this claim. An interesting recent example is the classroom experiment proposed by Wilson (2005). He notes:

> The median voter model is one of the basic building blocks for political economy. The model assumes that voters have single-peaked preferences over a single policy dimension. This means that each voter has a single preferred position that can be mapped onto the policy dimension and the voter's utility decreases as a function of distance from that preferred position. Candidates seek election by proposing a policy position that will be implemented if elected. Voters then compare the utility they get from the policy position proposed by each candidate. In a two-candidate model the median voter's position is in equilibrium and candidates converge to the equilibrium. *The simplicity of the model and its unique equilibrium allows those teaching various aspects of political economy to quickly cut through the complexity of political elections.* (p. 913, emphasis added).

Wilson has it exactly right: the spatial model we usually employ self-consciously abstracts from complexity, and this modeling device has proved extremely useful. The question is then what happens when complexity is added back in? Our answer is that the results of the model are changed, in ways that help us understand incumbency advantage in the spatial model.

Though Fenno's argument about perceptions is not primarily spatial, it goes directly to the treatment of complexity in the spatial model. Since candidates act on their "perceptions" of the district, complex (heterogeneous) districts are much harder for the candidate to understand, and finding what Fenno calls a "lowest common denominator", (p. 5) or unifying theme may be difficult. Perceptions of challengers are much less likely to be accurate in complex districts; consequently, incumbents should be more secure the more complex the make-up of interests in the district. As Axelrod (1973, p. 1248) points out, "The world is complex, and yet people are able to make some sense out of it". It is quite possible, of course, that "making sense" of a complex electoral problem involves an attempt to adapt, or update, perceptions. Interestingly, this seems quite consistent with Fenno's participant observations of House members:

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> Working back and forth incrementally from "last time" to "this time" helps the congressman to delineate his reelection constituency. It helps because election results provide him with one of the few certainties he operates with. He knows that he won "last time" and by how much. Sometimes, that is all he knows. (Fenno, 1978, p. 10).

Our theoretical point of departure is that, even if the incumbent knows nothing more than "I won last time, and by how much", that may be enough to explain the existence of incumbency advantage.

The incumbency advantage reconsidered

Assuming full knowledge and turnout by all voters, and the requirement that incumbents run on their record, incumbents should always lose if the policy space has dimension two or greater. Yet incumbents often win, and in some cases (House Democrats in the 1960 s and 1970 s; Senate Southern Democrats in the 1950 s and 1960s) seem nearly invulnerable. Why?

A number of "incumbency advantage" explanations have been offered. Many are plausible, but are ad hoc, at least in the context of the spatial model. Tacking on claims about uncertainty or personal affect in voters' minds after the fact may be quite correct, but it comes dangerously close to carrying out Green and Shapiro's (1994) criticism of rational choice theory's "moving-target" brand of theory. To be sure, explanations of incumbency advantage may be important reasons for real election differentials enjoyed by office holders. Some of the most important reasons for persistence of incumbency effects include the following:

- Franking privilege, or the use of subsidized mailing for delivery of "information" about the candidate's activities to constituents. (See, for example, Cover, 1978; Cover & Brumberg, 1982).
- Entry deterrence, as high quality challengers wait, or seek other office (Banks & Kiewiet, 1989; Bianco, 1984; Cox & Katz, 1996).
- Free media attention, and a forum for campaign messages in the context of the office itself (Mann, 1978; Mann & Wolfinger, 1980).
- Institutional advantages, deriving from incumbents' desire for opportunities for credit-claiming, name recognition, and position-taking (Mayhew, 1974).
- Differential abilities to deliver constituent services (Fiorina, 1977, 1979), or establish a "personal" connection through campaign style and staff devotion to constituents (Cain, Ferejohn, & Fiorina, 1989; Coates, 1995).

The question that motivates us in the present research project is quite different from the explanations for the "real" incumbency advantage outlined above. One reason is that real elections offer an extraordinarily complicated setting, in which a variety of effects and interactions have to be separated and identified. But the other reason is that it seems likely that there is a more fundamental explanation for incumbency advantage, one that derives from the variation in the complexity of the problem facing the candidate at the most basic level.

Thus, rather than relying upon ad hoc explanations for incumbency advantage, it may be that we need to study two quite different features of elections. First, we need reliable complexity measures for different electoral contexts – i.e., what is the "nature" of a given

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district?[1] Is it characterized by a complex set of disagreements or is it simpler? In the experiments described below, the "electorate" faced by a subject will vary in complexity, in order to test the implication that incumbency advantage should be greater in a more complex setting, even accepting the assumptions and limitations of the spatial model, and without adding any additional "advantages" for incumbents. Second, we need to measure the mental models or perceptions used by candidates and other political actors. As we will show using the experiments presented below, not all mental models are equal.

Experimental design

The experiment required the subjects to play the role of a challenger in 25 independent election trials against one opponent, an incumbent.[2] The subjects were informed that each election trial was independent (i.e., that the outcome of one election had no impact on the outcomes of those that followed). The experiment asked subjects to choose a platform in a 20×20 two-dimensional space, in which neither the axes nor cells were labeled. The locations of all voters and the incumbent were clearly visible at the beginning of each trial and were determined as follows:

- Voters were distributed over the 400 cells by defining each as an independent draw from a multivariate discrete distribution defined over the set of integers in the closed interval [1, 20] in both the horizontal and vertical dimensions. Since there were 1000 voters, most of the 400 cells contained 1 or more voters, and some contained 7 or more. In the "uniform" condition, the distribution was uniform; in the "noncentral" condition, the distribution of voters was drawn from a highly skewed multivariate normal, with mean located near one of the sides of the grid, and a line of symmetry organizing the distribution into a single dimension with variation around that line of symmetry.[3,4]
- The incumbent's position was determined by calculating the vector of means (rounded to the nearest integer), and then randomly permuting 1 or 2 units on each axis.[5]

The subjects were informed that *all* of the simulated voters would cast their ballot for the closest candidate in the two-dimensional space. If a subject asked what this meant, the instruction was repeated verbatim, with no further explanation.

Subjects were randomly assigned to one of two experimental conditions, "uniform" (complex), and "noncentral" (a much simpler, more structured, but noncentral distribution). There

[1] For an overview of complexity measures and their role in voting models, see de Marchi (1999), as well as chapter 5 of de Marchi (2005).

[2] The subjects were Duke University undergraduate students, recruited through flyers posted around campus. As far as we can tell, none of them had been exposed to multidimensional (2 dimensions or more) models of spatial political competition.

[3] Code is available from the authors on request.

[4] We conceived of the extreme distribution as being "ideological", or involving the collapse of the two policy dimensions into a single, arbitrary dimension in the space, as suggested by Hinich and Munger (1994). But there is nothing important about this interpretation; any restriction to a simpler space with error is appropriate.

[5] The position of the incumbent position was determined by calculating the vector of means (rounded to the nearest integer) and then randomly permuting ± 1 or 2 units on each axis. That is, the incumbent was located in a position that had two crucial properties: (1) there existed at least one feasible platform for the challenger/human player that defeated the incumbent in a majority rule election; and (2) the incumbent occupied a very advantaged position, compared to a random draw, approximating a process of "electoral selection" compared to other candidates with less electoral fitness.

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were 45 subjects for the uniform landscape and 28 subjects for the noncentral landscape. The uniform distribution is more complex because there is not a visible area of voter concentration, which is not the case for the noncentral distribution. The subjects were not informed about the nature of this assignment, nor did they know that there were two different conditions. Subjects were told that they would be playing 25 trials, and that each new trial would re-initialize both the distribution of voters and the incumbent location. They were not told that the experimental condition on the underlying distribution (uniform or noncentral) would be maintained for all trials, and it may or may not have been obvious to subjects that the underlying distribution was fixed. In any case, the realized pdf from which the distribution was drawn changed markedly from one trial to another.[6] Obviously, this implies that the position of the incumbent also moved with each trial.

The payment for each subject was a combination of two things, both of which subjects were informed about prior to beginning the election trials. First, subjects were paid a flat rate of 10 dollars for participating. In addition to this flat rate, subjects were paid based on the average percentage votes received for all 25 trials. More specifically, subjects were paid the product of their average percentage of votes for all 25 elections and 30 dollars.

After each election trial, subjects were provided with four pieces of information. First, they were informed whether the incumbent or the subject won the last election. Second, they were provided with their percentage of the total vote for the last election. Next, they were provided with a running tally of the number elections won so far. Finally, they were given their current average percentage of votes. The instructions provided to subjects are included in an appendix.

Variables

The variables used in the analysis come from three sources: a pre-experiment questionnaire, a post-experiment questionnaire, and the computer program used for the experiment. The computer program recorded the percentage of votes for the challenger (the subject, who tried to form a "perception" of the desires of the 1000 voters in the virtual district) and the incumbent in each trial, as well as the "best" possible outcome for the challenger. The program also recorded the trial number and the total time spent for all 25 election trials. The pre-experiment questionnaire had subjects provide demographic information and asked several questions about campaigns and elections. The post-experiment questionnaire had subjects provide information about their strategy and perception of the experiment.

Dependent variables

From the computer program output, we computed two *dependent* variables: (1) **VOTE**: The number of votes out of 1000; and (2) **WIN:** A dummy variable which took the value 1 for subject victory (i.e., the vote proportion exceeded 50% + 1), or else 0 for defeat.

Treatment

The primary experimental manipulation is cross-sectional, since the landscape was constant for any given subject (i.e., if the subject played on a uniform landscape in the first trial,

[6] Each trial was a unique draw from the distribution. Thus the sequence plays was not identical for each subject but only probabilistically the same.

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she played on uniform landscapes throughout the rest of the experiment, through trial 25). We hypothesize that overall performance would be better in the more structured, simpler noncentral landscape. We include a dummy variable, **NONCENTRAL** (1 = noncentral landscape, 0 = uniform landscape).

Mental models

To capture the mental model(s) of the subjects in these experiments, we include a set of explanatory variables created from an open-ended survey question as part of the pre-experiment questionnaire that asked subjects how they thought real political candidates take positions on issues. Four dummy variables were created from these responses, based on whether one or more of the following four factors were *mentioned* in the open-ended response: (a) the positions of voters or **CITIZENS**; (b) the candidate's own **BELIEFS**; (c) the position of the other **CANDIDATE**(s); and (d) the position of political **PARTIES**. We hypothesize that those subjects who believe that the position of citizens and the position of other candidates are important will perform better in the election trials because of the logic of vote maximization. We also expect that those subjects who believe that the candidates' beliefs and the positions of the political parties are important in explaining candidate issue positioning will not perform as well in the election trials.

Control variables

In addition to analyzing the impact of a subject's mental models, it is necessary to control for some other factors that may influence performance. We hypothesize that performance in choosing platforms should improve in later trials, due to learning. However, we also argue that the marginal returns from additional experience will decrease over time because there is a limited amount of information to extract from the experimental setting. To account for these factors, we included both **TRIAL** and **(TRIAL)**^{2}, which we expect will have positive and negative signs, respectively.

The cross-sectional variables used to explain performance were the amount of attention/effort and a set of idiosyncratic political characteristics of each subject. It is entirely possible that the attention, or motivated effort, of subjects varied significantly. Since the task subjects were asked to perform is both tedious and computationally demanding, a subject who didn't really pay attention is likely to perform poorly, quite independent of landscape type. One way we tried to mitigate this problem is make subject compensation based partly on performance, but the difference between those who performed well and those who performed poorly was probably not large enough to remove the problem entirely. Consequently, we controlled for the difference in attention by accounting for the time subjects spent on the experiment. All else equal, a very short time spent indicates little attention, and a long time spent indicates high attention. As is the case with learning over time, we expect that the marginal returns to additional effort will decrease as the amount of time devoted to choosing platforms increases. Thus, we included **TIME** and **(TIME)**^{2} and expect that the coefficient estimates will be positive and negative, respectively.

We also created a set of explanatory variables from responses to a pre-experiment and a post-experiment questionnaire. The questionnaire was intended to provide some indication of interest and beliefs about political campaigns, in an effort to illuminate the mental models that subjects use to understand and solve the problem that the experiment presented. To tap political interest of the subjects, we used two questionnaire responses that asked how often the subjects voted and how interested they were in political events. The frequency of

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VOTING was coded as a five category ordinal variable ranging from "never" to "always vote". If interest in real campaigns coincided with an understanding of spatial competition, we hypothesize that the more often the subjects voted, the better their performance.

INTEREST in political campaigns was coded from self-placement on a 0–100 scale, with 100 being "highly interested". We hypothesize that those who are more interested in politics will perform better, though of course this effect may already by picked up by the "time" variable indicating increased attention (i.e., if people who are more interested in politics generally also spent more time on the experimental problem).[7]

Since the location of the voters and the incumbent were determined by a random draw from a known distribution at the beginning of each trial, the maximum possible number of votes differed between trials. Thus, to control for this we included a variable, **MAXIMUM**, which is maximum possible number of votes out of 1000 that the subject could have received for the trial. Given the incumbent location, this is a well-defined number, calculated by the computer program (but it was not revealed to the subject). **MAXIMUM** always equaled or exceeded 50 percent of the total votes in expected value. It is important to note that the optimal platform in some cases may be the same position as the incumbent, which has an expected value of 50 percent because indifferent voters randomly choose a candidate. In certain elections the only platform capable of defeating the incumbent was the same position of the incumbent. Therefore, to control for this we also adopted one explanatory variable from the post-experiment questionnaire. The question asked subjects to report whether they considered choosing the **SAME POSITION** as the incumbent.

See Tables 1a and b for a summary of the explanatory variables for the uniform landscape and noncentral landscape, respectively.

Results

Before turning to the results of the statistical analysis, we should restate our expectations. We have argued that the incumbency advantage may be due to the computational complexity of choosing a platform in an electoral landscape. Thus, the key experimental manipulation was the landscape: uniform versus noncentral. We expect that the subjects will do better in the **NONCENTRAL** landscape.[8] Further, if complexity is important for explaining incumbency advantage, we suggested that the success of challengers depends upon their mental model (**SAME POSITION**, **CITIZENS**, **BELIEFS**, **CANDIDATE**, and **PARTIES**), their allocation of resources (**TIME** and **(TIME)**^{2}), and experience (**TRIAL** and **(TRIAL)**^{2}).

To examine incumbency advantage in our virtual elections, we tested two different models. The first model was designed to explain what determined the subject challenger's ability to maximize given a constraint, the position of the incumbent. Thus, we ran Ordinary Least Squares (OLS) using **VOTE** as the dependent variable, which is the total number of votes out of the maximum possible 1000 votes. The model was estimated with robust standard errors

[7] An important question, raised by an anonymous reviewer, involves the possible correlation of the **INTEREST** variable with other included variables. Rather than include a correlation matrix with mostly insignificant results, we will just point out that the **INTEREST** variable as bivariate correlation with other variables ranging from 0.0 to −0.1, with most values being negative but with all clearly both substantively and significantly negligible.

[8] It seems plausible that if subjects perform differently in the two landscapes, they might learn at different rates also. But there is little evidence that this is true. We ran interactions between the time trend variable and the landscape/complexity variable, and conducted F-tests. The effect is not close to significant, though the sign on the interaction is in the expected direction. That is, the coefficient on the interaction indicates less rapid learning in the complex setting, though we have statistical confidence in this conclusion.

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Table 1 Summary of explanatory variables for (a) uniform landscape and (b) noncentral landscape

Variables	Definition	Expected impact on performance	Mean	Min	Max
(a) Uniform Landscape					
TRIAL	Election trial number	Positive	13	1	25
$(TRIAL)^2$	Trial × Trial	Negative	221	1	625
TIME	Total time spent for all 25 elections (coded in minutes)	Positive	19	7.75	59
$(TIME)^2$	Time × Time	Negative	455	60	3481
VOTING	Ordinal variable 4 = Always 3 = Often 2 = Sometimes 1 = Rarely 0 = Never	Positive	1.8	0	4
INTEREST	Self-reported interest in politics on a 0 to 100 scale	Positive	53.5	10	95
CITIZENS	Dummy variable 1 = Mentioned 0 = Not mentioned	Positive	0.8	0	1
BELIEFS	Dummy variable 1 = Mentioned 0 = Not mentioned	Negative	0.64	0	1
CANDIDATE	Dummy variable 1 = Mentioned 0 = Not mentioned	Positive	0.06	0	1
PARTIES	Dummy variable 1 = Mentioned 0 = Not mentioned	Negative	0.29	0	1
SAME POSITION	Dummy Variable 1 = Mentioned 0 = Not mentioned	Positive for uniform landscape, neutral for noncentral landscape	0.29	0	1
(b) Noncentral landscape					
TRIAL	Election trial number	Positive	13	1	25
$(TRIAL)^2$	Trial × Trial	Negative	221	1	625
TIME	Total time spent for all 25 elections (coded in minutes)	Positive	19	6.7	38
$(TIME)^2$	Time × Time	Negative	451	46	1444
VOTING	Ordinal variable 4 = Always 3 = Often 2 = Sometimes 1 = Rarely 0 = Never	Positive	1.7	0	4

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Table 1 (*Continued*)

Variables	Definition	Expected impact on performance	Mean	Min	Max
INTEREST	Self-reported interest in politics on a 0 to 100 scale	Positive	57.6	25	95
CITIZENS	Dummy variable 1 = Mentioned 0 = Not mentioned	Positive	0.9	0	1
BELIEFS	Dummy variable 1 = Mentioned 0 = Not mentioned	Negative	0.6	0	1
CANDIDATE	Dummy variable 1 = Mentioned 0 = Not mentioned	Positive	0.04	0	1
PARTIES	Dummy variable 1 = Mentioned 0 = Not mentioned	Negative	0.5	0	1
SAME POSITION	Dummy variable 1 = Mentioned 0 = Not mentioned	Positive for uniform landscape, neutral for noncentral landscape	0.04	0	1

to control for heteroskedasticity caused by the different landscapes and the expectation that over the course of the trials subjects will be more likely to adopt a particular strategy.[9] The results are reported in Table 2.

The analysis presented in Table 2 shows that the performance of the subjects improved with experience, as we hypothesized. Thus, over the course of the experiment subjects adopted positions closer to the incumbent. The coefficients for the **TRIAL** and **(TRIAL)**^{2} variables are statistically significant with the expected signs. The coefficient on **TRIAL** is positive, which implies that the subjects' performance improves the more experience they have choosing platforms. The coefficient on **(TRIAL)**^{2} is negative, which implies that marginal return to experience declines over time.[10] We find a similar effect for the effort that subjects employed, which is measured by **TIME** spent on all 25 trials. The coefficient on **TIME** is positive and statistically significant. This indicates that as the total time dedicated to the experiment increased, that the subject's ability to optimally locate increases. However, there is also a decreasing marginal return to effort, which indicated by the negative and statistically significant coefficient estimate for the **(TIME)**^{2} variable.[11] Thus, both experience and effort had a meaningful impact on performance in the ways that we hypothesized.

[9] Robust standard error estimation is required because there is a sharp decline in variance over the sample, for most of the subjects. The reason is that early trials vary widely, sometimes encompassing the entire range of possible response, as subjects investigate how the game works. But fairly soon (for most subjects) the range narrows, and by the last few trials the range of answers is confined to a fairly small space near the center of the distribution of voter preferences. Consequently, the dispersion of response has a classic left-facing "horn" shape, indicative of heteroskedasticity.

[10] The regression line/curve estimated for the **TRIAL** and **(TRIAL)**^{2} variables reaches a maximum at about the 23rd trial. Thus the estimated average returns to experience peak before the end of the 25 trials.

[11] The regression line/curve estimated for the **TIME** and **(TIME)**^{2} variables reaches a maximum at about the 59 minutes, which is the maximum value in the data set.

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Table 2 OLS regression on percent of vote

Explanatory variables	Coefficient	Standard error
TRIAL	7.166**	1.017
$(TRIAL)^2$	−0.156**	0.035
TIME	4.073**	0.596
$(TIME)^2$	−0.034**	0.010
VOTING	9.612**	1.434
INTEREST	−0.153*	0.088
CITIZENS	19.753**	5.406
BELIEFS	−8.749**	3.569
CANDIDATE	27.267**	7.491
PARTIES	0.526	3.803
SAME POSITION	25.393**	4.941
NONCENTRAL	14.617**	4.622
MAXIMUM	0.481**	0.113
CONSTANT	54.305	57.176
R^2	0.22	
N	1825	

*Significant at the 0.1 level
**Significant at the 0.05 level
Dependent variable is the total number votes received out of 1000 possible
Model was estimated using Stata 8.2 with robust standard errors (i.e., the Huber/White/sandwich estimator of variance was used)

As noted above, we also measured familiarity with the electoral process, which could explain the subject's ability to locate an optimal platform. We used the variables **VOTING** and **INTEREST** to tap political awareness. Familiarity with the electoral process not surprisingly seems to have an impact on the ability of the subjects to find optimal platforms. The coefficient on the **VOTING** variable is statistically significant and positive, suggesting that greater experience with the political process leads to better performance. However, self-reported **INTEREST** in political campaigns is negative, which is not in accord with our expectations. Thus, interest in politics does not appear to matter for the decision task presented to the subjects.

While familiarity may be important, we argue that perceptions or the subject's mental model are crucial. These variables represent the subjects' perceptions of how real world candidates take positions on issues. There are four variables coded to capture what subjects mentioned as important for the taking positions on political issues: citizens, beliefs, other candidates, and political parties. Interestingly, subjects who mentioned the views of **CITIZENS** as important performed better, while those who mentioned the candidates' **BELIEFS** as important performed worse. The coefficient on **CITIZENS** is positive and statistically significant, while the coefficient on **BELIEFS** is negative and statistically significant. Further, those subjects that thought the position of the other candidate was important in candidate decisions also faired better in the experiment. The coefficient on **CANDIDATE** is positive and statistically significant. Again, recall these responses were collected from the *pre*-experiment questionnaire. It seems that those who initially thought the position of other political actors was important faired much better in the laboratory. Thus, the subjects' mental model(s) had important implications for their performance. Also as expected, subjects who "discovered" and employed the strategy of choosing the **SAME POSITION** as the incumbent performed better.

Finally, but most importantly, we bring attention to the coefficient on **NONCENTRAL**: it is statistically significant and positive. Thus, after controlling for experience, effort, mental models, and for the maximum possible votes that the subject could receive, subjects did better

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Table 3 Probit regression on probability of winning

Explanatory variables	Coefficient	Standard error	Min	Max	First difference
TRIAL	0.061**	0.021	1	25	2.0%
$(TRIAL)^2$	−0.001*	0.001	–	–	–
TIME	0.032**	0.014	6.5	59	8.3%
$(TIME)^2$	0.000	0.000	–	–	–
VOTING	0.074**	0.031	0	4	0.6%
INTEREST	−0.001	0.002	25	95	−0.1%
CITIZENS	0.378**	0.115	0	1	0.9%
BELIEFS	−0.065	0.081	0	1	−0.1%
CANDIDATE	0.344**	0.158	0	1	0.8%
PARTIES	0.026	0.075	0	1	0.0%
SAME POSITION	0.364**	0.106	0	1	0.9%
NONCENTRAL	0.654**	0.094	0	1	2.3%
MAXIMUM	0.012**	0.002	500	635	15.5%
CONSTANT	−8.633**	0.891	–	–	–
$\chi^2_{(13)}$		277.28**			
N		1825			

*Significant at the 0.1 level
**Significant at the 0.05 level
Dependent variable is a dummy variable for whether the election was won or lost (1 = win, 0-loss)
Model was estimated Stata 8.2 with robust standard errors (i.e. the Huber/White/sandwich estimator of variance was used)
The first differences are calculated by comparing the change in probability from the minimum observed value to the maximum observed value, while holding all other variables at their mean. Note that the first difference for **TRIAL** and **TIME** is the joint effect of the variable and its squared term

under the more structured, less complex distribution of voters.[12] This offers support for our main contention that the complexity of political landscapes may have important implications for explaining the incumbency advantage.

We wanted to investigate not only the impact of effort, experience, and complexity on vote totals, but also to see their impact on the probability of winning. Using a probit model with **WIN** as the dependent variable, coded 1 for a challenger win and 0 for a challenger loss, we use the same explanatory variables as before. This model was also estimated with robust standard errors. The results are reported in Table 3.

Not surprisingly we find effects similar to those in Table 2. Table 3 reports first differences for each variable, which is the change in the predicted probability that is calculated by

[12] A reviewer suggested that we might consider running a random effects version of the model, to capture uncorrelated idiosyncratic differences across subjects that are not captured in the model. But the technique employed here is to compare the two landscapes, and to compare learning rates, by individuals. A "fixed effects" model would allow us to capture these mean differences, but too many of our covariates are fixed in time to allow a fixed effects estimation. A random effects model assumes that there is no underlying unobserved fixed value. Rather, there is a distribution with the usual properties, and that *distribution* is fixed. But there is no way of knowing that the particular value is in any one instance, because the dispersion is an inherent property of the population. We can't really say anything about individuals. The problem is that trying to estimate (in effect) the parameters of that distribution vastly increases the size of confidence intervals in any one parameter, since the values (apparently) in our population vary so widely. We think it would be a plausible solution to try to nail down more *variables* that explain these differences. But using a random effects model explodes the size of the standard errors so much as to make nearly any estimation impossible.

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varying the explanatory variable from its minimum to maximum value while holding all other variables at their mean value. We will focus just on the **NONCENTRAL** variable. On average, the subjects in the less complex, noncentral landscape had a 2.3 percent higher probability of winning. Although this effect is not large in absolute terms, relative to the other explanatory variables in the model it does appear to be a significant factor in explaining performance. Thus, these results show that the complexity of the political landscape may be an important factor in explaining the incumbency advantage.

Discussion and conclusion

In this paper, we have used a simple experiment with human subjects to illustrate a problem that has routinely been recognized, but not tested explicitly. This is the problem of full information complexity. The particular context placed the subjects in the role of a challenger facing an incumbent with a fixed location in a two-dimensional policy space. It is not clear, and we do not claim, that there is sufficient external validity to this context to be able to draw dispositive conclusions about real elections.

Nonetheless, the results are interesting. Challengers with full information (complete knowledge of voter preference distribution and incumbent location) were still unable to find the optimal solution. We illustrated that subjects learned over the course of repeating the experiment 25 times, and the variables which would be expected to condition learning were shown to do so. Further, we found support for our main hypothesis that the more structured, less complex political landscapes would lead to better performance.

The most surprising, and potentially most important, result was the finding that the conception of the game itself (which we have called the subject's "mental model") has a consistent, and statistically significant, impact on performance. Subjects with a conception of politics which can easily be adapted to the spatial competition problem appeared to have solved the problem faster and better. That is, subjects who told us that they believed that voter distribution and/or incumbent location matters in real elections learned more quickly, and their overall level of performance was higher. Subjects who emphasized the importance of candidate values and beliefs had a much harder time with the problem, learning more slowly and performing overall at a lower level.

Appendix: Instructions for experiment

Welcome. This study is on decision making. If you agree to participate in today's experiment, you will be paid a ten-dollar flat rate plus an additional amount based on your performance. This payment system will be explained later. Today's experiment will last no longer 90 minutes.

Before we proceed with today's experiment, we are going to ask you to fill out a brief questionnaire. Please take all the time you need to fill out this questionnaire and feel free to ask any questions.

Today's experiment is a series of computer-simulated elections. Your actions will be recorded and logged in the computer. During the experiment you may have questions. If you do, please raise your hand and I will assist you. Please do not communicate with any of the other participants at any time during the course of the experiment. I am now going to ask everyone to turn and face the computer screen. Please turn on the monitor by pushing the button on the bottom right of the monitor.

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The experiment is a computer-simulated election model in which you will play the role of a candidate. Each election will have a total of two candidates, which includes an incumbent and you the challenger. You will be asked to participate in 25 elections. Please note that outcome in one election has no bearing on the outcomes of the other elections.

The election will take place in a two-dimensional grid, which should be visible on the screen in front of you. Every box represents a possible platform. You will compete with the incumbent by choosing a platform.

Platforms will be represented by a diamond-shaped token. A green diamond will represent the platform of the incumbent. Your platform choice will be represented as a gray diamond. The election will proceed as follows. The platform of the Incumbent will be revealed to you at the start of each election. You will then choose your platform. To choose your platform, click the "check box" at the right of the screen and drag the mouse pointer to the position where you want to locate.

In each election there will be 1000 voters. In the upper left corner of each box you will find a number that represents the number of voters who prefer that platform. So for example, if a box is labeled 5, that means that 5 of the 1000 voters prefer that platform the most. Voters in the election will cast their vote for the candidate whose platform is closest to their preferred platform. Are there any questions?

As stated earlier, you will be paid ten dollars plus an additional amount based on your performance. This additional amount will be determined by the percentage of votes received for all 25 elections. We will multiply the average percentage of votes received by 30 dollars. Thus, if you averaged 1/3 of the vote for the 25 elections, you would get 10 dollars plus the additional ten dollars for participating.

Remember that voters will cast their ballot for the candidate that is closest to them. The candidate with the most votes will be the winner. After each election, you will be notified of the winner at the top of the screen. When the winner has been revealed, you may then proceed to the next election by clicking the arrow highlighted in blue at the very top-left of the screen. Are there any questions?

Remember that the outcome of one election has no effect on the other elections. The number of elections completed is recorded in the upper right corner of the screen. To the right of the number of elections completed, there is a display that indicates the number of elections won. To the right of that, is a display that indicates the percentage of votes collected in the last election. Next to that, there is a display that indicates your average percentage of votes received for the number of elections completed. Finally, on the top right of the screen is a display that indicates the winner of the last election.

After 25 elections have been completed, please sit quietly while we calculate your final payment. Are there any questions? Now that you are ready to begin, please click the arrow highlighted in blue at the very top-left of the screen.

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