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VODYS: An Agent-Based Model for Exploring Campaign Dynamics

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Abstract

The literature on campaigns has considered a number of factors that affect whether and how someone votes, including demographics, campaign strategies, and social milieu. Understanding the dynamics of campaigns, however, is complicated by the fact that researchers cannot observe much of what happens during an election cycle. Typically, studies rely on voter recollections of conversations, contacts, and media exposure. In addition, because data are collected at discrete points in time, most models of voter turnout cannot capture the dynamic nature of an individual's interactions during a campaign cycle. Agent-based models offer a way to overcome these data limitations by allowing us to model the dynamics of voter turnout over the course of many weeks as individuals move back and forth between home and work environments, interacting with neighbors and colleagues. In this article, the authors present an agent-based model of campaign dynamics, VODYS, and conduct three simulations to demonstrate the utility of agent-based models for exploring the effects of contact and context on political behavior.

Keywords

agent-based models: voting behavior, political campaigns, political participation, influentials, diversity, segregation, Downs' spatial theory of elections

Political scientists have long been interested in understanding what factors affect whether and how someone votes. In addition to the role of individual characteristics, researchers have been increasingly interested in the effects of campaign strategies and social context. To answer questions about the effects of context and campaigns on behavior, researchers have used several methodologies, each with its own set of advantages and drawbacks. For example, survey data provide detailed demographic information about individual respondents but relies on individuals to accurately recall conversations, contacts, and media exposure during the course of a campaign. Alternatively, a researcher might extrapolate from information about the amount of campaign activity in a location to assign exposure measures to individuals, which may not accurately reflect the individual's actual experiences during the campaign. To counter some of these disadvantages, some researchers have

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used experiments to analyze the effects of contact and campaign activity on individual behavior. An advantage of this approach is that the researcher can be certain about the nature and extent of an individual's exposure to a campaign activity. A disadvantage, however, is that experiments generally examine the effect of a discrete event and do not reflect the dynamic nature of social contacts and campaign activities during an election cycle. In addition, ethical and practical concerns limit the scope of experiments.

Agent-based models, which allow the researcher to simulate the effects of contact and campaign activities on individuals in a virtual world, offer another, complementary way to approach these research questions, but they have not yet been widely used by researchers interested in political behavior. To explore the ways in which agent-based models can help us understand the potential effects of campaign dynamics and social context on voter behavior, we have developed an agent-based model of campaign dynamics, VODYS,[1] the Voter Dynamics Simulator, which can serve as an experimental platform to explore campaign dynamics in ways that can complement the insights gained from empirical studies. As time passes in our simulated community, individual agents behave according to specified rules (either theoretically derived or hypothesized for exploratory purposes), allowing us to observe how campaign dynamics play out over a specified number of weeks in a particular context.

In the first section of the article, we review existing literature on the relationship between contact, context, and voting behavior and explain the advantages of using agent-based models to understand these relationships. Next, we present the specific design features of VODYS: how the virtual world is constructed and what characteristics and behaviors are assigned to individual agents. In the third section, we describe three sets of simulation experiments that demonstrate the utility of VODYS for exploring the effects of contact and context on voting behavior. In the first simulation, we consider the role of influential community members in encouraging voter turnout. In the second simulation, we consider the ways in which contact effects on voting behavior are shaped by the specific racial context in which voters reside. In the third simulation, we consider how campaign activities may affect voting behavior over the course of a campaign.

Research on Contact, Context, and Voting Behavior

Early research on voter turnout tended to focus on individual determinants of voting behavior—demographic (e.g., education and income) and psychological factors (e.g., efficacy and confidence in government), as well as political engagement and knowledge (See Berelson, Lazarsfeld, & McPhee, 1954; Campbell, Converse, Miller, & Stokes, 1960; Converse, 1964). More recently, research has focused on the social nature of political life, where social networks of friends, family, coworkers, neighbors, and activists foster participation by creating social benefits for the individual, such as approval and respect. Over time, these interpersonal networks create a capacity to participate, motivate, and reinforce participation, and help develop skills relevant to politics (Putnam, 2000; Rosenstone & Hansen, 1993; Verba, Schlozman, & Brady, 1995).

If "[p]olitics is a social activity, imbedded within structured patterns of social interaction" (Huckfeldt & Sprague, 1995), then studies of voting behavior need to account not only for individual characteristics of voters but also for the social milieu in which they move. Research on the effects of living in particular racial, ethnic, and economic contexts has consistently found that location affects political behavior (Butler & Stokes, 1976; Huckfeldt, 1979; Key, 1949/1984). Oliver (2001) finds that population size, as well as race and income homogeneity, affect whether residents vote in local elections and Tam Cho, Gimpel, and Dyck (2006) report that the percentage of fellow ethnics in a neighborhood affects participation levels of Asian Americans.

Although most of this work focuses on residential context, Mutz and Mondak (2006) argue that work context may be even more significant for its potential to affect political attitudes. The workplace involves "involuntary association"—individuals spend long amounts of time on a regular basis with people not of their choosing. As a result, they find that individuals are more likely to be exposed to opposing political views at work than at locations such as neighborhood or church. Mutz and Mondak are focused on the way in which the workplace can affect political tolerance and understanding. However, if the workplace is a significant location for political socialization and if "socialization and learning processes at specific locations produce particular political attitudes, including decisions about whether to vote" (Tam Cho et al., 2006, p. 166), then we might also expect work context to affect voter turnout.

In some instances, research on the effects of social contact has focused on the specific role of political parties and campaign workers. Considerable literature addresses the question, "do campaigns matter?" and argues that at best, campaigns have only a minimal impact on voting decisions (Finkel, 1994) and election outcomes (Holbrook, 1996). More recently, some have argued that campaign activities can indeed have a significant effect on voter behavior, as shown through experimental research designs (Green & Gerber, 2004; Nickerson, Friedrichs, & King, 2006), innovative measurement strategies (Goldstein & Freedman, 1999), and correctly specified models (Hillygus, 2005; Shaw, 2006; Zaller, 1992). For example, Hillygus (2005) argues that to correctly estimate campaign effects, researchers need to account for the original vote intention of individuals, prior to campaign exposure. In this way, she finds that "campaign efforts [including contact] have substantial influence on turnout intention" and that the influence is larger for voters who initially do not intend to vote. However, despite the strong beliefs among campaign professionals that what they *do* has the power to affect election outcomes, the bulk of political science research remains largely skeptical about the effects of campaign activities beyond activation and reinforcement (Gelman & King, 1993; Iyengar & Petrocik, 2000).

Modeling Voter Turnout

Although a great deal of research has explored various social influences on voting, understanding the dynamics of voter turnout is complicated by the limitations of available data and empirical techniques. The most common approach is to draw from one or more large random surveys of individuals, which ask respondents questions about their attributes, opinions, and behaviors. Even with a large sample size and numerous questions, researchers still are unable to observe much of what happens during an election cycle. Such studies typically rely on voter recollections of conversations, contacts, and media exposure, which introduces considerable measurement error (Page & Shapiro, 1992; Stimson, Mackuen, & Erikson, 1995). With survey data, there is "the inevitable gap that arises between the imputed meaning of the variables under investigation, as specified in theories under test, and the real measurements used to indicate the values taken on by those variables in specific cases" (Lustick et al., 2004, p. 211). These studies also have difficulty in measuring the quality or intensity of the interaction.

Second, because data are collected at discrete points in time, most models of voter turnout, including those analyzing panel data, cannot capture the dynamic and iterative nature of an individual's interactions during a campaign cycle. All of these studies look at political interactions as isolated, additive encounters between individual and candidate/organization. The reality is that when people have an encounter that changes their behavior, they might then affect the behavior of others that they meet. In their in-depth study of residents of South Bend, Indiana, during the 1984 presidential election, Huckfeldt and Sprague (1995) point out that "the electorate is socially organized in ways that make it misleading for purposes of systematic political analysis to extract an individual citizen from a particular social location" (p. 21). For example, parties do not have to contact each voter to affect behavior, expecting that targeting their message to particular individuals in "particular locations within the social structure ..." leads to the "further diffusion of their messages" as these individuals communicate with friends, neighbors, coworkers (p. 22). The effects of contact and context extend from a particular individual, touching others with whom that individual has contact and affecting the context as it is experienced by others who share the same geographical space.

Finally, most studies of the effect of social context and contact on turnout concentrate on one particular context—that is, neighborhood or workplace. In reality, we know that individuals are situated in multiple contexts and each context may assert political influence, the net effects being cumulative across different contexts. Consequently, we argue that some of this literature could underestimate the effects of contact and context on the behavior of potential voters.

An Agent-Based Modeling Approach to Voter Behavior and Campaign Dynamics

An alternative approach to capturing the dynamic, iterative, and cumulative nature of campaigns and voter behavior is to use an agent-based computer simulation. Agent-based models offer a way to overcome some of the data limitations described above. Although a researcher cannot follow multiple individuals around all day, directly observing their interactions with neighbors and others and their exposure to campaign activities and continually measuring their vote intention, a computer simulation does allow us to do all of these tasks. We can model the dynamics of voter turnout over the course of many weeks as individuals move back and forth between home and work environments, interacting with neighbors and colleagues. In fact, we can even use such a model as an experimental platform to explore the relative strength or relationships among various campaign components independent of any particular application to a real community. The result can be the emergence of patterns not previously anticipated but worthy of further study (Epstein & Axtell, 1996, p. 6), as illustrated later in connection with our simulations.

Using agent-based models to simulate social phenomena is not new. Since at least the 1940s, economists have used simulation models to analyze traditional economic problems (Amman, Kendrick, & Rust, 1996), and, today, these models are used widely in a variety of disciplines (Billari, Fent, Prskawetz, & Scheffren, 2006; Kollman, Miller, & Page, 1992; Miller & Page, 2007). Agent-based models have been used sparingly in political science, although other computer simulation techniques have been used to model political behavior and analyze the role of institutions for almost 50 years (Johnson, 1999). Although there are some exceptions (e.g., see Bloomquist, 2006; Cohen, 1984; Kollman et al., 1992; Whicker & Strickland, 1990), most of the recent agent-based models have examined questions emerging from international relations and comparative politics (e.g., see Axelrod, 1997; Bhavnani & Backer, 2000; Cederman, 1997; Cederman & Gleditsch, 2004; Miodownik & Cartrite, 2006). For example, Lustick et al. (2004) have used agent-based models to explore competing hypotheses about what kinds of institutional arrangements are most likely to avert secessionist movements by geographically concentrated ethnic minorities. They explain the utility of agent-based models by stating:

> If theoretical expectations are relatively clear, but data are hard to find that reliably match theoretical categories ... computer simulation should be considered a logical complement to other techniques of analysis. Such simulation involves creating a virtual world in which the basic theoretical relationships among individuals or groups are implanted directly, obviating the need for surrogate measures or indices of key variables .... By randomizing perturbations and/or initial conditions and collecting data on the trajectories produced by the 'landscape' as it moves forward in time (with 'agents' interacting and taking or maintaining values depending on the algorithms with which they are endowed), researchers can systematically conduct the thought experiments that they cannot conduct or observe in the real world .... (p. 212)

This approach is particularly useful for understanding campaign dynamics because of the great difficulty of gathering data relevant to the important interaction effects of interest.

The utility of experimental models, such as VODYS, has also been widely recognized for highlighting research issues in a definitive framework that encourages the identification of poorly understood relationships, as well as the generation of hypotheses to test about these relationships (Hilborn & Mangel, 1997, p. 27). In fact, it is often the more qualitative experimental results (e.g., when X goes up, why do we see Y going down?) that point out dynamic processes that might otherwise have escaped attention (Epstein, 2007, p. 21; McElreath & Boyd, 2007, p. 7), an observation borne out repeatedly by the current authors during the 3-year development of VODYS. Much of the focus of our experiments, although using the best data we have available, is intended to investigate the complex dynamic processes underlying campaign effects rather than trying to make precise numerical estimates or predictions.

The Virtual Community of VODYS: Agents, Landscape, Campaign Activities, and Interactions

We begin by describing the VODYS program itself, which we have developed as a public domain model using the NetLogo simulation language.[2] The model tracks the evolution of various voting characteristics of the members of a biracial community over time, as members of the community interact with each other both in their residential locations and in their "activity locations" (e.g., workplace, school, shopping, and community activity). The members, or "agents," may be exposed to various campaign-related phenomena such as general media intensity, partisan media messages, special campaign events, local issues of special interest, and interactions with so-called influentials. The user controls the framework for the simulations by specifying key characteristics, such as the size of the population, the breakdown into two racial groups, A and B, the extent to which the populations are segregated in both their residential and activity spaces, and the extent of income stratification of each racial group within its residential space. Underlying these and other aspects are a set of demographic characteristics (income, education, and partisan identification) that the user can control but for which the default values are based on national statistics. In addition, there are required sets of conditional probabilities both of turning out to vote and of voting for a particular party, based on the demographic variables, at the beginning of the time period for which the simulation applies. These two key variables, the probability of voting (i.e., if the election were held on a given day or time step) and the probability of voting for a particular party, are monitored for all the members of the population as various events, processes, and person-to-person interactions occur through a sequence of time steps (generally taken as weeks) during the campaign.

Figure 1 shows the general landscape populated by 5,000 individual agents from the two racial groups. The apparent clustering within each racial group results from a segregation algorithm and threshold level implemented during the setup routine, over which the user has control. (Income stratification is treated similarly.) In this figure, the agents are distributed in the residential space; and the activity space, which is the center part of the figure, is empty. In the next half-time step, the agents would all move to their normal locations in the activity space, except for some additional random variations that can be included. It has been shown in previous agent-based modeling studies (e.g., Epstein, 2007, for the case of smallpox) that the mixing effect of an activity space can be an important contributor to a broader impact of even localized phenomena. Thus, the resulting network topology reflects the two key characteristics of so-called small world networks: a local neighborhood for each individual agent (in our case, two such neighborhoods, one for the residence and one for activities) and a pattern of interconnectedness that leads to relatively short pathways between agents in all parts of the network. This latter is accomplished by the intermediary mixing effect of the second neighborhood.

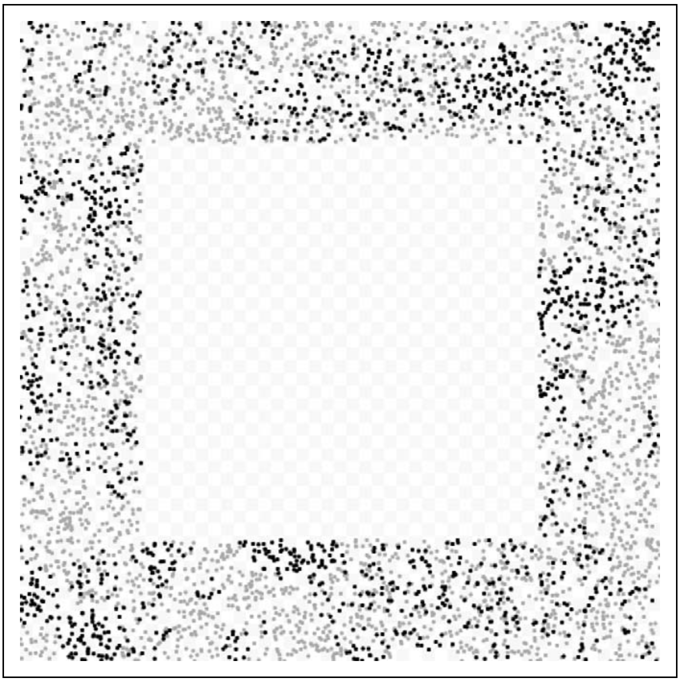

Figure 1. Landscape during residential period, showing racial distribution. Black dots are Group A members; gray dots are Group B members. The faint checkerboard pattern in the background shows the "patches," which are the localized areas of primary social interaction. A similar pattern would occupy the center during the activity period.

We have chosen to simulate segregation processes during the setup routine because, in reality, residential patterns in American communities do not emerge randomly, and specific neighborhoods do not reflect the demographics of the city or town as a whole. Rather, communities are segregated along racial and class lines (Dreier, Mollenkopf, & Swanstrom, 2002; Massey & Denton, 1998). Even as suburbia has become more diverse, particular suburbs still tend to be relatively homogeneous. VODYS actually simulates the emergence of historical patterns of racial and income segregation, by "growing" a community. Agents are first seeded randomly into the landscape and then are allowed to move to a more desirable location based on a set of mobility rules. To do this, we compute a similarity factor for each agent (i.e., the percentage of agents in a nine patch[3] grouping centered on an agent's patch that are of the same race) and then exchange the location of the agent with the lowest factor in racial group A with the location of the agent with the lowest factor in racial group B. This exchange raises the mean similarity factor for all agents and agents continue to be relocated until the overall mean reaches a level specified by the researcher. We also assume that most people's activity spaces will be somewhat segregated environments, although perhaps less segregated than their residential space (Mutz & Mondak, 2006), and thus we use the same procedure to read just the racial distribution in the activity space to meet a specified threshold. Residential patterns also are a result of household income levels, as homes of similar value tend to cluster together. To account for this, we perform a second rearrangement process by income within each racial group.[4] This approach allows as much clustering as possible to emerge from the experiment itself, avoiding the possibility of introducing the experimenter's subjectivity.

One can see in the background of Figure 1 an underlying checkerboard pattern, each square of which is referred to as a "patch." One can think of such patches as the local area around one's residence, such as a block or neighborhood, or a place of work or the corresponding social network. Agents undergo direct interactions with other agents who are occupying the same patch, or in some cases neighboring patches, and the basic result is for the key monitoring variables described above to gradually converge or "regress" to the mean of all the agents on the same patch. Thus, this part of the model essentially constitutes a diffusion process (Ghez, 2001). Interactions with influentials have a stronger effect in causing an agent's probability values to change and these values can also be affected by various campaign activities.

As discussed above, agents assume four theoretically important demographic and political attributes that have been shown empirically to have a significant effect on voting behavior (Rosenstone & Hansen, 1993; Verba et al., 1995). In the simulation results that we report later, each agent was designated either as a non-Hispanic White (Group A) or a non-Hispanic Black (Group B);[5] either having a college degree or not having a degree; earning less than $35,000, earning between $35,000 and $75,000, or earning above $75,000; and identifying either as a Republican, Democrat, or Independent. Rather than simply assigning these attributes randomly to each agent, we used the 2000 National Annenberg election Survey (NAES)[6] to estimate the proportion in the population for each of the 36 combinations of groups with these four attributes. We then directed our simulation setup to produce agents that would mirror these same proportions and randomly assigned them to cells in the residential areas. However, we stress that for further experimental exploration of campaign and voter dynamics or to support the development of campaign strategies in particular circumstances, it may be desirable to use quite distinct sets of values, as we illustrate in our second set of simulation experiments.

As Hillygus has discussed (2005), to understand how campaign dynamics affect turnout intention among potential voters, we need to know what the starting turnout probability is for each voter. One way to ascertain this would be to ask people about their vote intention, prior to the campaign. Although the NAES does ask people whether they intend to vote, this question is asked during different waves of the survey so that some respondents may already have been exposed to some campaign dynamics by the time they are asked. Instead, using the NAES panel survey, we estimated an initial probability of voting, that is, before the introduction of any campaign effects and based solely on fixed, pre-campaign variables. This was done by first using a binary logit model to estimate the effects of race, education, income, partisan identification, media exposure, political discussion, and contact with a campaign or candidate on reported voter turnout in 2000. We then used the coefficients to calculate turnout probabilities for each of the 36 groups.[7] The values for the campaign dynamic variables were set to 0, to generate probabilities for each subgroup, *in the absence of any campaign effects*.

Simulation Experiments

With our virtual world in place, we conducted several groups of simulation experiments designed to examine the relationships among individual voters, their social networks, their environment, and campaign activities. Our goal is to illustrate some of the ways in which VODYS can be used to explore hypotheses of interest to scholars who study political behavior and electoral politics.

Simulation I: The Role of Influentials

One series of experiments examined the role that networks of interpersonal communication have in encouraging voter turnout. In particular, we focused on isolating the direct and indirect effects that civic activists and opinion leaders may have on the rest of the community's voting probability. These so-called influentials are those whose opinions are held in high regard by others and who play a key communication role within their group by serving as gatekeepers and conduits of election information (Katz & Lazarsfeld, 2005; Lazarsfeld, Berelson, & Gaudet, 1944). Although the typical influential has a college degree, is affluent and employed in a professional job, owns a home, is older, married, and has young children, a significant fraction of them come from other walks of life as well. What really distinguishes them is their energetic personality and enthusiasm for political discussion and civic activity. They are also highly exposed to external sources of information (i.e., the news media and political campaigns) and consistently find themselves in contact with a wide variety of people in various social settings. Although people with the ‘‘influential personality’’ comprise roughly 10% of the population at any given time, this is not a static grouping of individuals who are involved in every aspect of the community. Many temporarily withdraw from high levels of activity and exposure because of lifestyle changes, while new people emerge for the same reason (Keller & Berry, 2003).

To this point, the role of influentials in encouraging voter turnout and political persuasion mostly has been captured in analyses of survey data. Survey respondents typically are asked whether they were contacted by anyone about the election and whether they discussed politics during the campaign with friends, neighbors, coworkers, and so on. In addition to measurement error introduced by poor recollections, these contacts are judged as qualitatively similar. For example, interactions occurring at the beginning of the campaign are not differentiated from interactions occurring as the campaign comes to a close and voters are more focused (Hillygus, 2005; Rosenstone & Hansen, 1993; Verba et al., 1995). Moreover, it is nearly impossible for surveys to measure the indirect effect of political communication, leaving unaccounted for the interaction between people after one or more have been exposed to election stimuli.

We introduce influentials into our model by first identifying the top one fifth of agents in terms of voting probability (i.e., the most politically active members of the community) and considering them as a pool of candidate or ‘‘latent’’ influentials. Then, depending on the number of influentials needed for a particular experiment ($n = 500$ for the experiment discussed in this section), these are then randomly selected from this candidate pool.[8] These agents retain their influential status in both the residential and activity space locations and can have an influence on other residents in the landscape by causing agents occupying the nine patches surrounding their location to have their voting probabilities migrate a certain fraction of the distance between their previous probabilities and the influential's probability. This would represent the direct effect of contact with civic activists. In survey research data, this effect would be captured by respondents answering in the affirmative that they had been contacted by someone about the campaign or discussed politics at work, with a friend, or a neighbor.

Influentials can affect the population in an indirect way as well through a diffusion process. After a resident has had contact with a civic activist at work, community event, or at the market, they return to their home with an increased enthusiasm for civic activity, which, in turn, is observed by the other residents in the same neighborhood. At the same time, these residents' enhanced appreciation for civic activity may abate somewhat when they themselves observe the intentions of their neighbors. With VODYS, we simulate the diffusion process by requiring that at every time step, each agent's voting probability migrates toward the mean of the voting probabilities of all the agents on the same or adjacent patches at a given convergence rate. Thus, an agent exposed to an influential in the activity space would return to the residential space with a higher probability of voting. Although that agent's probability would decrease slightly after converging on the mean of the surrounding agents, its net change would remain positive because influentials influence at a higher rate than the common agent, thus increasing the overall mean of agents in adjacent cells. Because influentials are described as opinion leaders and trendsetters (Keller & Berry, 2003), we make one exception to this rule: their voting probabilities are not subject to the diffusion process and thus do not migrate toward the mean of the group with whom they interact in the activity space or with their neighbors in the residential space.

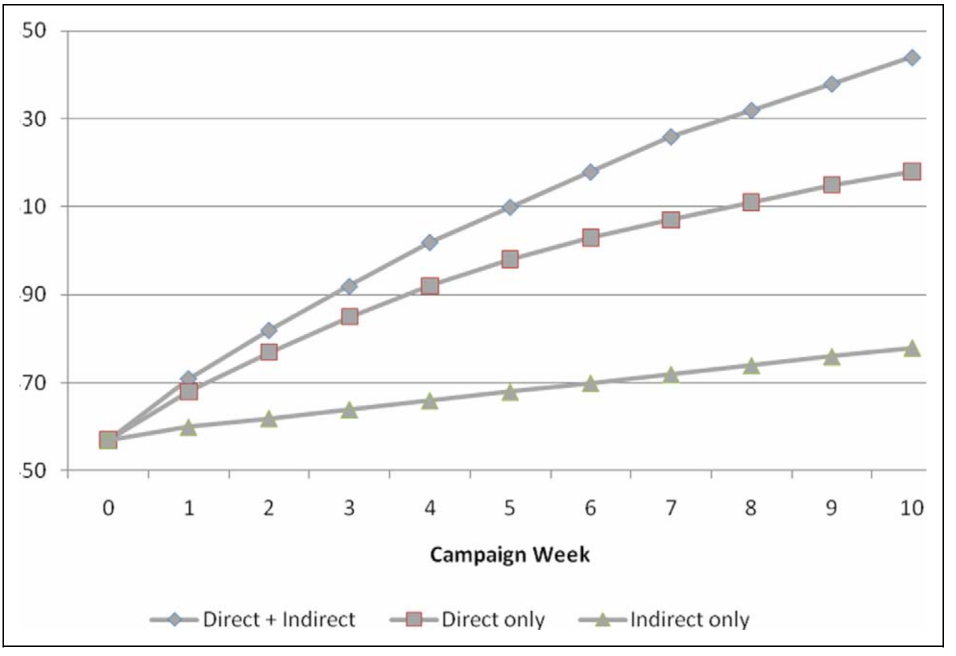

Figure 2. Expected turnout rate after contact with influentials.

Our first experiment examines the direct effect of contact with influentials on voter turnout, that is, what is generally observed with survey research data. Our second experiment examines how the direct contact with influentials in combination with the subsequent diffusion process affects voter turnout. The third experiment limits the examination to only the indirect effect. For all three experiments, we specified an 85/15 percent mix of A and B residents, a .75 mean similarity index for the residential space, and a .6 mean similarity index for the activity space. The initial mean probability of voting turnout for all 5,000 residents is .457. In the aggregate, this would mean that 45.7% of the residents would turn out to vote.

We assign influentials an influence level of twice that of the common agent. We also assume that individuals are influenced less by persons of a different race (Niven, 2004; Platow, Mills, & Morrison, 2000; Shaw, Garza, & Lee, 2000). To implement this assumption, we reduce the effect of contact and convergence by one half for agents of the opposite race. We limit the simulation to 10 time steps, with each step representing 1 week and 10 weeks representing roughly the traditional campaign season that begins on Labor Day. In the experiment meant to capture both the direct and indirect effects of contact, 1 week is complete after residents enter the activity space and interact with civic activists and coworkers and then return to their residential space and converge to the mean of their neighbors.

The week-by-week results for all three experiments are displayed in Figure 2. The results of the first experiment show that after the very first week ($t = 1$), the mean probability of voting for all agents increases from .457 to .468. Another week of interaction increases the mean to .477. After four additional weeks of contact in the activity space, the mean probability reaches .503, indicating that half of the eligible voters would vote, if the election were held at the end of the 6th week. Turnout intention continues to increase in the last 2 weeks. At the end of the 10th week, the mean probability is at .518. For this virtual world, therefore, average citizens' consistent contact with influentials for 10 weeks increases the mean probability of voting by .061, an increase in the percentage of voters from 46.7% to 51.8%. This change represents the cumulative direct effect of individuals' contact with civic activists.[9]

In the second experiment, the influence level of activists remained the same as in the first experiment, but the agents also converge toward the mean value of other agents on returning to their residential space. The change in the mean probability in the second experiment will represent the direct influence of interaction with influentials in the activity space and the subsequent indirect effect that is a result of the diffusion process in the residential space. As can be seen in Figure 2, the increase in turnout intention after the first week is very similar to what we observed in the first experiment, changing to .467 from an initial probability of .471. After the second week of interaction and diffusion, the mean probability increases to .482 and by the 4th week exceeds .50. At the end of the experiment, the mean probability is .544, an increase of .087 from the initial probability.

Comparing the results of these two experiments illustrates the relative contribution over time that diffusion makes to increasing voter turnout. In this simulation, including the indirect effect of contact results in an increase in the mean probability of voting after 10 weeks that is 2.6% greater than the increase observed when only the direct effect was included. This suggests that empirical studies of voter turnout that do not capture the indirect effects of contact may underestimate the impact that contact has on increasing political participation.

The importance of accounting for both the direct and the indirect effects of influential contact is further illustrated by the results of the third experiment, where we examined how excluding the direct effect of influentials can affect overall turnout. In this experiment, influentials are still present in the community, but they are not assigned a higher level of influence. But because they begin with a higher probability of voting and are not influenced by their neighbors' intentions, the mean probability of voting in their space will always drift upward. Thus, agents assigned to residential spaces with influentials nearby still will be influenced by them, albeit, indirectly, even if there is no direct interaction. This process would simulate a world in which residents go to work and do not discuss politics but observe some of their coworkers wearing political buttons or a banner in the window of a nearby office. When they return home, they do not discuss politics with their neighbors but may notice the yard sign next door or bumper sticker on the car parked in the driveway across the street.

After the first week, the absence of any direct effect by activists increases the mean probability of voting from .457 to only .460. Over the course of the 10 weeks, represented by the line with the triangle markers in Figure 2, the mean probability increased to only .478. Still, the presence of political activists in one's neighborhood increases overall turnout by 2%. Another way to measure the indirect influence is to calculate the inverse of the ratio of the direct change (.061) over the combined change (.087), which is 1.426. This ratio indicates that the indirect effect of influentials is about 43% of the direct effect under the assumptions of the model. Both measures show that simply having neighbors around you who are enthusiastic about politics can affect the entire neighborhood even without any overt persuasion taking place. Although the notion of a world in which voters only influence each other indirectly may be unrealistic, the three experiments together help us separate the direct and indirect contributions of civic activism and show how agent-based modeling can reveal important insights about the political process from experiments that cannot be practically achieved in the real world.

As described earlier, an advantage of the VODYS model is that the user can specify many features of the virtual community. To illustrate the extent to which results are sensitive to the user's specifications, we close the first simulation by replicating the three experiments in virtual communities of different sizes: one smaller than in our original community with 2,500 agents and one larger with 10,000 agents. The size of the network space remains the same and, thus, we are examining the effects of influentials at different levels of population density. The increase in the probability of voter turnout over the course of 10 weeks from both the direct and the indirect effect of influentials is highest in the community with the highest population density (.570) and is lowest in the community with the lowest density (.514). The closer proximity of residents to their neighbors makes it more likely that the average citizen will come into contact with an influential and thus increase their probability of voting. However, it is worth noting that the pattern of the change in the probability of voting over time in each population is nearly the same. The largest increase takes place after the first week and the rate of increase declines in each subsequent week.

Simulation 2: Changing Context and Voter Turnout

In this set of simulation experiments, we consider how expectations about the direct and indirect effects of contact on turnout intention may vary depending on the context in which individuals reside. As discussed earlier in the article, a number of researchers have explored the way in which voter turnout varies depending on the diversity of the community. Diversity has been conceived in various ways: race/ethnicity (Oliver, 2001; Tam Cho et al., 2006), economic/class (Huckfeldt, 1979; Oliver, 2001), and party (Gimpel, Dyck, & Shaw, 2004). In addition, findings have varied, with some suggesting that individuals in more diverse settings participate more (Gimpel et al., 2004; Oliver, 2001), and others suggesting the opposite (Oliver, 2001; Tam Cho et al., 2006). One possible explanation for inconsistent findings is that researchers are analyzing data drawn from different communities, which may vary on dimensions not captured in statistical models. In addition, research on context and individual behavior is often complicated by the difficulty of collecting data that reliably measure both individual *and* community characteristics (Gimpel et al., 2004, p. 348). Agent-based models offer researchers an additional tool for exploring questions about the effects of context on behavior. One advantage of using an agent-based model is that the researcher can specify all the relevant features of experimental communities, varying them in ways that are theoretically interesting and that allow precise comparison.

In this simulation, we vary context by degree of racial diversity and level of racial segregation. The degree of racial diversity refers to the relative proportion of the two racial groups, A and B, in the community. The level of segregation then measures the extent to which the two racial groups reside together or in separate areas of the community. We consider three levels of diversity: Group A makes up 65%, 50%, or 35% of the community. Clearly, many communities in the United States are much less diverse than is captured by any of these proportions of A and B. However, to examine the effects of segregation as well as diversity, we need to look at communities with significant levels of both groups to observe differences in turnout effects when the two groups reside together or separately. We compare communities with levels of racial segregation that range from least segregated, an average mean similarity factor of .5 in the residential space, to the most segregated, an average mean similarity factor of .9 in the residential space. To compare the effects of different levels of segregation with different proportions of A and B residents, we increase the community size for this set of experiments from 5,000 to 20,000 residents. As in Simulation 1, we assume that individuals are more influenced by others of the same race than by those of a different race. We also assume that 10% of residents are influentials and include both direct and indirect effects on political behavior. For each ratio of A to B residents and varying levels of segregation (simfactors), we then run multiple 10-week simulations and compare the average change in turnout that results in each context.

The results of these experiments generate several interesting insights about the way in which contact effects may vary across contexts (Figures 3, 4, and 5). First, the relative size of the change in turnout (i.e., the overall impact, direct and indirect, of contact) is largest for both A residents and B residents in communities with higher percentages of A residents (marked by triangles in Figures 4 and 5). This is true across all levels of segregation. At the same time, the effects of contact over the 10 weeks (percent change in turnout) are always larger for B residents than A residents (compare the y axis for Figures 4 and 5). Because of their lower initial average turnout, the impact of convergence is stronger on B residents than on their A neighbors. Interestingly, this is clearly the case even though we assume at the outset that cross-race contacts are less influential than same-race contacts. Because B residents, on average, experience a much larger percentage increase in

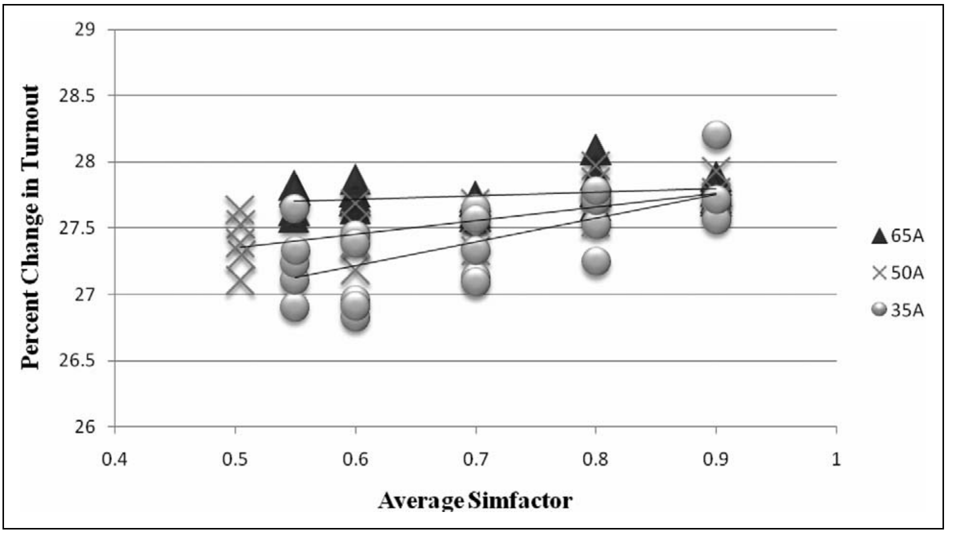

Figure 3. Total turnout.

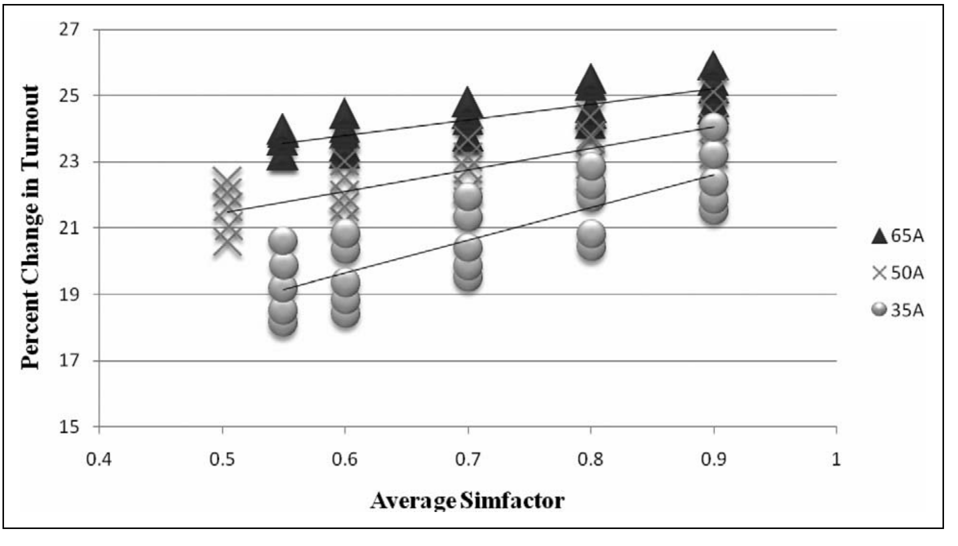

Figure 4. Turnout A.

turnout than A residents, total turnout (i.e., including both A and B residents) does not always increase the most in communities with larger numbers of A residents (Figure 3). In fact, as segregation levels increase, the size of the total change in turnout converges for all three levels of diversity (65% A, 50%A, and 35%A) and is sometimes larger in communities with more B residents—the reverse of the pattern for turnout of A and B considered separately. The second pattern that emerges from these results is in the differences between the most and least segregated communities. Looking first at the results for all residents, the change in turnout is consistently higher in the most segregated communities, for all three levels of A population (Figure 3). Separating out percent change in turnout for both A and B residents, however, reveals some additional contextual effects that are not apparent

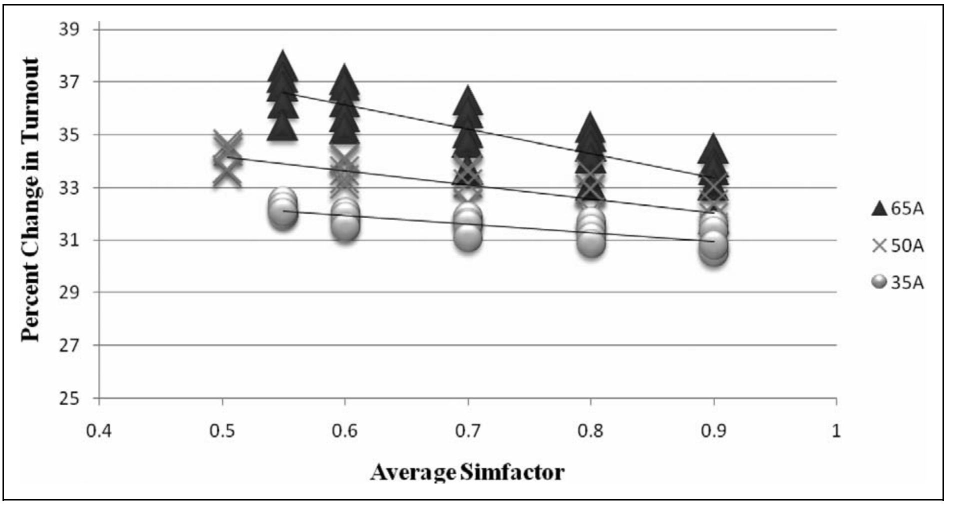

Figure 5. Turnout B.

when looking only at total turnout. Looking at A residents, the differences between the most and least segregated communities is even stronger (Figure 4). For example, in a community that is 35% A residents, percent change in turnout is almost three points higher in the most segregated community (.9 average simfactor) than in the least segregated (.5 average simfactor). This pattern holds across the other two levels of A residents. However, the pattern is actually reversed for B residents (Figure 5). For all three levels of A residents, percent change in turnout for B residents declines as segregation levels in the community increase from .5 average simfactor to .9 average simfactor.

Simulation 1 demonstrated that contact with neighbors and colleagues can have substantial effects on turnout over the course of a campaign. Simulation 2 illustrates that this contact effect will vary depending on how individuals are organized within the community. The size of the effect depends on both the relative proportions of the two racial groups and their degree of segregation. These results suggest that research on the effects of neighborhood diversity on political behavior needs to take into account not only the level of diversity, that is, the relative proportion of different groups, but also the degree to which members of one group have relatively close neighbors from another group. In addition, these results suggest that within the same community, the effects of contact may work differently for different residents: that is, groups with relatively high turnout rates who live in communities with a significant percentage of the relatively low turnout group will see a greater increase in turnout probability when they are highly segregated. In contrast, groups with relatively low turnout rates who live in a community with a significant percentage of the high turnout group will see a greater increase in turnout probability when they are highly integrated.

Simulation 3: Campaign Events and Voter Intention

A third series of experiments builds on the two previous simulations by introducing campaign effects into the model and tracking voters' candidate preference. For this particular simulation, we examined the role of campaign events, such as campaign rallies, canvassing efforts, and candidate appearances in stimulating turnout and winning votes. We specifically consider how the effect of these events on turnout and preference varies depending on where in the community that event is introduced. When organizing a rally or scheduling a personal appearance by the candidate, campaigns not only must settle on the appropriate location but also on which constituencies to target (Shaw, 2006). Would the results be better for the campaign to stimulate turnout in areas and constituencies of high support or would it be better to target undecided voters and independents with an objective of converting them to your side? While it clearly would be best to pursue both strategies simultaneously, the lack of financial and organizational resources precludes following that course. Moreover, there is a limit to just how many communities a candidate can visit. These decisions become even more difficult when deciding to involve the candidate in the more time-consuming efforts such as canvassing and walk-throughs.

Surprisingly, neither empirical research nor experiments have been able to demonstrate which of these alternative mobilization strategies is the most effective for winning votes. The more conventional view among scholars, journalists, and practitioners is that the candidate who can capture the center will have the best chance of winning the election. Because neither party commands the support of a majority of the electorate, each candidate must appeal to voters outside their partisan base (MacRae, 1952; Key, 1942; Schattschneider, 1942). An alternative theory suggests that it is better for parties and candidates to limit their appeal to their core constituencies and maximize turnout among this group of crucial supporters (Fiorina, 1974; Huntington, 1950; Miller, 1970). There remains considerable disagreement within the literature over which of these strategies is the most effective and which strategy candidates actually pursue (Griffin, 2006; Gulati, 2004).

Downs' (1957) spatial theory of elections seemed to have reconciled these two competing views by showing that a centrist strategy works best in a context where there is wide ideological consensus in the electorate, while a mobilization strategy works best when the electorate is polarized between two major groups. However, subsequent spatial theorists who subjected Downs' model to a formal mathematical analysis showed that the parties should converge to the median or mean, regardless of how voter preferences were distributed (Davis, Hinich, & Ordeshook, 1970). We suggest that agent-based models have the capability of helping to resolve this controversy by assessing the effectiveness of both strategies relative to each other in a more complex environment.

In our model, campaign events can be introduced at specific locations in the residential or activity space during a given week. Candidates can hold one or more events in a week in different locations and hold events in multiple weeks. The impact of each event is in the area surrounding its location, specified in the model as all patches within a user supplied radius. Not everyone within the radius is exposed to the event, however. Individuals from the same party are assumed to be most likely to attend the event or learn about it through media reports, while those from the opposing party are assumed to be the least exposed (Sniderman, Brody, & Tetlock, 1993; Zaller, 1992). An exposure parameter of .5 would mean, for example, that 50% of the agents from the sponsoring party will be influenced by the event.

The impact of the event takes two forms: it increases the voting probability of anyone exposed to the event and it also increases the probability that such exposed individuals will vote for the party sponsoring the event. The extent to which the event increases these probabilities is controlled by an event strength parameter, which ranges from 0 (no effect on anyone) to 1 (makes everyone's probabilities within the event radius increase to 1.0 for the current week). An event strength parameter of .8, for example, moves each affected agent's probability of voting by .8 of the distance between its current probability and one. Influentials also are affected by events and the diffusion process proceeds in the same way as described in the first two experiments. To decide on where to introduce an event, the model has the capability to identify the patches with the highest concentrations of Democrats, Republicans, and Independents. This option allows the researcher to assess the impact of the centrist, base, and other mobilization strategies relative to each other.

As in our previous experiments, a certain percentage of agents are designated as influentials at the beginning of the simulation. VODYS has the capability of introducing additional influentials over the course of the campaign. These influentials are typically individuals who do not become active until news media coverage of the campaign becomes more intense or becomes exposed to a

Table 1. Effects of Campaign Events on Turnout and Vote Preference, A/B Ratio = 50/50

	Exp. 1	Exp. 2	Exp. 3	Exp. 4
Segregation: residential space	.750	.750	.900	.900
Segregation: activity space	.600	.600	.900	.900
Segregation: income, Group A	.0369	.0369	−.0010	−.0010
Event type	Dem.	Dem.	Dem.	Dem.
Target group	Dem.	Ind.	Dem.	Ind.
Turnout				
All (.435)	.567	.551	.574	.559
Dem. (.437)	.593	.560	.604	.567
Ind. (.340)	.504	.502	.505	.506
Rep. (.555)	.578	.592	.575	.606
Dem. preference				
All (.675)	.730	.735	.729	.730
Dem. (.952)	.961	.962	.961	.961
Ind. (.612)	.658	.676	.653	.672
Rep. (.105)	.136	.187	.123	.178

Note. Dem. = Democrat; Exp. = Experiment; Ind. = Independent; Rep. = Republican.

campaign event. For our experiments in the third simulation, we designated one fourth of the latent influentials (i.e., 5% of the total population) as active at the beginning of the time period and then activated a certain percentage of additional latent influentials each week until the percentage of agents designated as influentials reaches a maximum value, which we set at 10% for this simulation. Latent influentials who are exposed to a campaign event have a greater probability of becoming active.

Our first two experiments examine the impact of an event on voter turnout and vote preference in a community of 5,000 residents with a 50–50 split between racial groups A and B and a moderate level of segregation in the residential and activity spaces. The initial mean probability of voting turnout for all agents is .435 and the mean probability of voting for the Democratic candidate for those voting is .675. The high level of initial support for the Democrat is the result of half of the population, that is, Group B, supporting the Democrats at a rate of over. 90. In one experiment, one event per week is introduced by the Democrats in an area with a high concentration of Democrats for 10 consecutive weeks. In a second experiment, one Democratic event per week is introduced in an area of a high concentration of independents.[10] We set the impact of the event to a radius of five patches with an event-strength parameter of .5 and assign exposure parameter values of .8 to copartisans, .4 to independents, and .2 to cross-partisans.

As can be seen in the first column of data in Table 1, introducing a series of 10 Democratic events in areas with a large proportion of Democratic voters increases the overall mean probability of voting to .567 and the overall mean of voting for the Democratic candidate to .730. In addition, as can be seen in the second column of Table 1, introducing events in an area with a large proportion of independent voters leads to an increase in voter turnout to .551 and Democratic preference to .735. Thus, in a highly diverse and moderately segregated context, both strategies yield virtually the same return for the Democrats and would be equally as effective.

Disaggregating the results by party shows how the two strategies lead to almost identical outcomes. In the first experiment, the focus on Democrats is more effective than a focus on independents in increasing turnout among Democrats (59.3% vs. 56%), although it has almost no impact on the percentage of Democrats voting Democratic (96.1% vs. 96.2%). But while the focus on independents is no more effective in increasing turnout among independents (50.4 vs. 50.2%), it does lead to

Table 2. Effects of Campaign Events on Turnout and Vote Preference, A/B Ratio = 65/35

	Exp. 5	Exp. 6	Exp. 7	Exp. 8
Segregation: residential space	.700	.700	.900	.900
Segregation: activity space	.600	.600	.900	.900
Segregation: income, Group A	.0395	.0395	.0004	.0004
Event type	Dem.	Dem.	Dem.	Dem.
Target group	Dem.	Ind.	Dem.	Ind.
Turnout				
All (.445)	.567	.568	.583	.554
Dem. (.444)	.597	.585	.624	.589
Ind. (.344)	.499	.513	.507	.413
Rep. (.557)	.581	.594	.585	.637
Dem. Preference				
All (.600)	.657	.667	.663	.669
Dem. (0.937)	.948	.951	.949	.950
Ind. (.559)	.598	.626	.600	.645
Rep. (0.084)	.108	.140	.104	.161

Note. Dem. = Democrat; Exp. = Experiment; Ind. = Independent; Rep. = Republican.

a modest increase in the percentage of independents voting Democratic (65.8% vs. 67.6%). Thus, in the more integrated context, the mobilization strategy succeeds by increasing Democratic turnout while the centrist strategy succeeds by persuading more independents to vote Democratic. In the end, however, targeting one group is roughly equivalent to the increases in turnout and votes from targeting an alternative group.

A similar pattern is observed in a comparison of the results of the third and fourth experiments, which are simulations in communities with high levels of segregation. As can be seen in the third column of Table 1, introducing a series of 10 Democratic events in areas of high concentrations of Democrats increases overall turnout to .574 and preference for the Democratic candidate to .729. In addition, as can be seen in the fourth column of Table 1, introducing the events in areas with a high concentration of independent voters increases turnout to .567 and Democratic preference to .730. As in the more integrated context, the differences in the results for Democratic preference of the two experiments in segregated contexts are quite modest and again suggest that both strategies would be equally effective, albeit through a different path.

Our next four experiments (5–8) examine the impact of an event on voter turnout and vote preference in a community with a 65–35 split between racial Groups A and B. The initial mean probability of voting turnout for all agents is .445 and the mean probability of voting for the Democratic candidate for those voting is .600. The results of these experiments are presented in Table 2 and show some support for adopting the centrist strategy. With a moderate level of segregation, introducing a series of 10 Democratic events in areas with a large proportion of Democratic voters increases support for the Democratic candidate to .657, whereas introducing events in an area with a large proportion of independent voters increases support for the Democrat to .667. And with a high level of segregation, introducing 10 Democratic events in areas with a large proportion of Democrats increases support for the Democratic candidate to .663, whereas introducing events in an area with a large proportion of independent voters increases support for the Democrat to .669.

In every pair of experiments to this point, the centrist strategy has yielded a better result, although the benefit does not seem always to be consequential. Our next four experiments (9–12) examine the impact of an event on turnout and vote preference in a less diverse community, where there is an 85–15 split between racial groups A and B. The initial mean probability of voting turnout for all agents is .457 and the mean probability of voting for the Democratic candidate for those

Table 3. Effects of Campaign Events on Turnout and Vote Preference, A/B Ratio = 85/15

	Exp. 9	Exp. 10	Exp. 11	Exp. 12
Segregation: residential space	.756	.756	.900	.900
Segregation: activity space	.752	.752	.900	.900
Segregation: income, Group A	.0341	.0341	.0093	.0093
Event type	Dem.	Dem.	Dem.	Dem.
Target group	Dem.	Ind.	Dem.	Ind.
Turnout				
All (.457)	.581	.584	.572	.573
Dem. (.457)	.609	.607	.614	.592
Ind. (.348)	.518	.527	.500	.516
Rep. (.558)	.601	.607	.581	.601
Dem. preference				
All (.504)	.579	.582	.560	.573
Dem. (0.91)	.931	.930	.922	.925
Ind. (.499)	.563	.575	.531	.564
Rep. (0.07)	.120	.125	.076	.120

Note. Dem. = Democrat; Exp. = Experiment; Ind. = Independent; Rep. = Republican.

voting is .504. The results of these experiments are presented in Table 3 and show clear support for the benefits of the centrist strategy. In a community with moderate levels of segregation, a series of 10 Democratic events in areas with a large proportion of Democrats increases the probability of voting for the Democratic candidate to .579, whereas 10 similar events in areas with a large proportion of independent voters increases the probability of voting Democratic to .582 (see the first and second columns of Table 3). The benefits of the centrist strategy are even more pronounced in a community with a high level of segregation. In the segregated context, introducing a series of 10 Democratic events in areas with a large proportion of Democrats increases the probability of voting for the Democratic candidate to .560, whereas introducing 10 similar events in areas with a large proportion of independent voters increases the probability of voting Democratic to .573 (see the third and fourth columns of Table 3).

Examining the disaggregated results for each partisan group helps explain why the centrist strategy is more effective in winning votes for the Democratic candidate in a highly segregated, less diverse context. The focus on Democrats is more effective in increasing turnout among Democrats (61.4% vs. 59.2%), although it makes almost no difference in increasing the percentage of Democrats voting Democratic (92.2% vs. 92.5%). Targeting independents, however, produces a large increase in the proportion of independents (53.1% vs. 56.4%) and Republicans (7.6% vs. 12%) voting Democratic. Although there is a substantial drop-off in Democratic turnout (61.4% vs. 59.2%), there is almost no difference in the percentage of voters voting Democratic (92.2% vs. 92.5%). We then replicated all of the experiments for Republican events and observed the same outcomes that were found for Democratic events, except in the case of Experiments 11 and 12, where the advantage of the centrist strategy was quite modest.

The centrist strategy in an environment that has a small percentage of African Americans and is segregated along racial lines is more effective for Democrats because the areas with a high number of independents have even fewer Democrats since almost all of the African American voters are concentrated in other parts of the community. Thus, there is even more potential of exposing a larger proportion of independents and Republicans to a campaign event. Put another way, in a segregated context, there are fewer resources wasted on convincing voters who already support your candidate to vote. And at the same time, voters who were not targeted are affected as well and provide an unexpected benefit to the campaign. However, while targeting core supporters is highly efficient at increasing turnout among copartisans, it can do little to convert voters because the level of support among Democrats already is very high. Furthermore, the mobilization strategy in a segregated context means that very few White independents and Republicans will be exposed to Democratic events. This particular dynamic may explain why many White Democratic candidates in the South who have positioned themselves in the center have been more successful than the Democrats' more progressive nominees (see e.g., Glaser, 1996). Outside the South, however, it may not matter which strategy is followed but only that a strategy be meticulously executed. In addition, for Republicans, either strategy would yield similar results because of the absence of near unanimous support from a particular racial or ethnic group.

On the whole, these results follow the predictions of the post-Downsians' models (Davis et al., 1970), which show that an appeal to the median voter is the best campaign strategy. However, more importantly, these results reveal some important insights about the dynamics of alternative mobilization strategies and suggest another way of addressing important controversies in the campaigns literature. Agent-based models allow the researcher to incorporate many community- and campaign-specific characteristics into a simulation simultaneously, thereby providing practitioners with a better understanding and more concrete map of what the likely consequences might be for pursuing one particular strategy rather than another.

Conclusions

There are three main logical components to this article. First, we have demonstrated the challenges facing existing methodology in answering important questions about campaign dynamics and the impact of campaign activities on voters. Second, we have introduced an additional tool that can be used to explore many of these issues either prior to or in concert with the use of traditional methodologies. Third, we have demonstrated this process through three simulation exercises that show how such modeling can provide further insight and new ideas for investigation and thus sharpen the focus of ongoing research.

In the first set of experiments, we demonstrated how statistical analysis of survey data may underestimate the impact of political discussion on voter turnout. With our simulation, we are able to estimate the direct effect of contact with influentials and neighbors over the course of a campaign without relying on individuals to accurately recall the level of contact and discussion that they experienced. In addition, we are able to observe and isolate the *indirect* effect that contact with neighbors and influentials has on overall turnout levels. Researchers have assumed that contact has an indirect as well as a direct effect on voting behavior. However, this indirect effect is extremely difficult to measure using survey data. In our series of experiments, the indirect effects of contact accounted for an additional 2.5% increase in turnout, meaning that any estimate of contact effects that ignores indirect effects may be underestimating the true importance of contact on voter behavior.

We demonstrated in the second set of experiments that the impact of contact with neighbors and influentials depends in part on the context in which this contact occurs. In particular, we find that the effect of contact is shaped by both the degree of racial diversity and the extent of racial segregation in a particular community. Furthermore, these effects are experienced differently by different members of the community. In mixed race communities, the racial group with a lower initial turnout rate experiences the largest increase in turnout when the community is integrated. However, the racial group with the higher initial turnout rate experiences the largest increase in turnout when the community is segregated. Because ours is a simulated community, we are able to specify exactly the combination of community characteristics in which we are interested and we are able to rerun the same campaign cycle multiple times in communities that vary only on the dimensions of interest.

In the third set of experiments, we demonstrated the way in which VODYS can be used to explore competing hypotheses about the impact of campaign events on both voter turnout and party preference. In particular, we find that the impact of an event depends on the partisan makeup of the targeted neighborhood and the level of racial segregation in a particular community. An event targeted at independents appears to be the most effective electoral strategy and even more so when a community is highly segregated. However, an event targeted at copartisans appears to work just as well as an event targeted to independents when a community is more integrated. As in Simulation 2, an agent-based model allows us to specify exactly which characteristics of our community we wish to vary while holding other characteristics constant across multiple runs of an election cycle. In addition, we are able to specify the extent of exposure to the event in a way that would not be possible in empirical work.

The initial results of using VODYS to analyze voting behavior are encouraging. We are able to explore existing research questions in ways that overcome some of the limitations of more traditional approaches such as survey research and experiments. Its individual submodels are based on specific effects that have been noted in the literature and their quantitative representation follows a simple linear structure such as one encounters in a wide range of diffusion processes in many contexts. The parameter values that govern the rates of these processes are under the control of the user and can be varied continuously to explore the relative strengths of the processes. It would be unrealistic to interpret the input parameters or the model results in an absolute numerical sense, at least at this relatively early stage of VODYS experimentation and exploration. Rather, the model should be regarded as a user-friendly experimental platform for exploring the propagation of the impact of various campaign activities through both direct and indirect effects, for comparing the impacts of alternative campaign activities, and for investigating the sensitivity of such results to the demographic and racial context. The three simulation experiments discussed in this article illustrate these uses and lead naturally to further research questions and new hypotheses that can be explored with a combination of further empirical and modeling studies.

Notes

1. This model is available for download at http://vodys.org, which has complete documentation.
2. VODYS is a highly adaptable model; not all features are illustrated in this article.
3. Patches, small blocks of the landscape, are discussed further in the next paragraph.
4. There is less freedom for this relocation routine than with race and it usually ends by reaching a default condition of negligible change from one step to the next. There is an asymmetry in structure between the simulation factors used for racial segregation and those used for income. In the racial case, the most segregated case corresponds to a factor of 1, where all of one's neighbors are of the same race. Thus, during setup, the values increase. In the income case, the simulation factor is a measure of income difference between a person and his neighbors of the same race, so the limiting case would be 0, corresponding to income parity. Setting the threshold at 0 guarantees that this income readjustment will go as far as possible before reaching the default condition of no further adjustment being possible.
5. For the current simulations, we have limited the number of characteristics and categories because our objective is to describe a fundamental process, that is, the dynamic role of social networks and to understand more clearly the interplay among certain key variables.
6. The 2000 National Annenberg Election Survey is actually a series of surveys that were conducted over the course of the 2000 campaign. For our study, we relied exclusively on the pre–post general election panel study of 6,508 eligible voters. This panel was constructed by reinterviewing respondents randomly selected from a series of national cross-section samples conducted between December 1999 and January 2001. Its large sample size allows us to generate more reliable estimates of attitudes and behaviors for a variety of smaller subgroups. It also consists of over 200 questions, including responses to questions pertaining to media use, contact with presidential campaigns, political participation, political orientation, and voting behavior.

7. We could have generated probabilities for each subgroup simply using the observed turnout rate in the NAES sample. The problem with that approach is that some of the subgroups, the groups consisting of Blacks and Republicans in particular, have very small sample sizes. Calculating probabilities from a multivariate model allows us to overcome this problem using all of the available information in the data set for each particular subgroup.
8. The model also allows a dynamic process for selecting influentials. Rather than designating agents as influentials at the beginning of a simulation and keeping them active throughout, the user can designate an initial group of influentials (e.g., 5%) and then activate latent influentials every week from the pool of agents in the top one fifth in terms of voting probability that were not selected initially until a user-specified maximum percentage of influentials is reached.
9. We tested for the possibility that there may be some variation in the results from one simulation to another for a given set of input parameters by repeating the first experiment 10 times. The results were remarkably similar across simulations. Considering that there are so many probabilistic components to each calculation, the results tend to "average out" to their means.
10. We identify distinct areas of high concentration of the targeted groups for such events by counting the number of members of the group within the user-specified concentration radius of each patch, then creating a decreasing list of target patches from this set such that each element is at least two distance units away from any previous patch in the list.

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References

Amman, H. M., Kendrick, D. A., & Rust, J. (1996). *Handbook of computational economics.* (Vol. 1). Amsterdam, The Netherlands: Elsevier Science B.V.

Axelrod, R. (1997). The dissemination of culture: A model with local convergence and global polarization. *Journal of Conflict Resolution*, *41*, 203-226.

Berelson, B. R., Lazarsfeld, P. F., & McPhee, W. N. (1954). *Voting: A study of opinion formation in a presidential campaign.* Chicago, IL: The University of Chicago Press.

Bhavnani, R., & Backer, D. (2000). Localized ethnic conflict and genocide: Accounting for differences in Rwanda and Burundi. *Journal of Conflict Resolution*, *44*, 283-306.

Billari, F., Fent, T., Prskawetz, A., & Scheffren, J. (2006). *Agent-based computational modeling.* Heidelberg, Germany: Physica-Verlag.

Bloomquist, K. M. (2006). A comparison of agent-based models of income tax evasion. *Social Science Computer Review*, *24*, 411-425.

Butler, D., & Stokes, D. (1976). *Political change in Britain.* London, England: St. Martins Press.

Campbell, A., Converse, P. E., Miller, W. E., & Stokes, D. E. (1960). *The American Voter.* New York: Wiley.

Cederman, L. (1997). *Emergent actors in world politics: How states and nations develop and dissolve.* Princeton, NJ: Princeton University Press.

Cederman, L., & Gleditsch, K. S. (2004). Conquest and regime change: An evolutionary model of the spread of democracy and peace. *International Studies Quarterly*, *48*, 603-629.

Cohen, M. (1984). Conflict and complexity: Goal diversity and organizational search effectiveness. *American Political Science Review*, *78*, 435-451.

Converse, P. (1964). The nature of belief systems in mass publics. In D. E. Apter (Ed.), *Ideology and discontent.* New York, NY: Free Press.

Davis, O. A., Hinich, M. J., & Ordeshook, P. C. (1970). An expository development of a mathematical model of the electoral process. *American Political Science Review*, *64*, 426-448.

Downs, A. (1957). *An economic theory of democracy.* New York, NY: Harper & Brothers.

Dreier, P., Mollenkopf, J., & Swanstrom, T. (2002). *Place matters.* Lawrence: University of Kansas Press.

Epstein, J. (2007). *Generative social science.* Princeton, NJ: Princeton University Press.

Epstein, J., & Axtell, R. (1996). *Growing artificial societies: Social science from the bottom up.* Washington, DC: The Brookings Institution.

Finkel, S. E. (1994). Reexamining the "minimal effects" model in recent presidential campaigns. *The Journal of Politics*, *55*, 1-21.

Fiorina, M. (1974). *Representatives, roll calls, and constituencies.* Lexington, MA: D.C. Heath.

Gelman, A., & King, G. (1993). Why are American presidential election campaign polls so variable when votes are so predictable? *British Journal of Political Science*, *23*, 409-451.

Ghez, R. (2001). *Diffusion phenomena: Cases and studies.* New York, NY: Springer.

Gimpel, J. G., Dyck, J. J., & Shaw, D. (2004). Registrants, voters, and turnout variability across neighborhoods. *Political Behavior*, *26*, 343-375.

Glaser, J. (1996). *Race, campaign politics, and the realignment in the South.* New Haven, CT: Yale University Press.

Goldstein, K., & Freedman, P. (1999). Measuring media exposure and the effects of negative campaign ads. *American Journal of Political Science*, *43*, 1189-1208.

Green, D. P., & Gerber, A. S. (2004). *Get out the vote*! *How to increase voter turnout.* Washington, DC: Brookings Institution Press.

Griffin, J. (2006). Electoral competition and democratic responsiveness: A defense of the marginality hypothesis. *Journal of Politics*, *68*, 911-921.

Gulati, G. J. (2004). Revisiting the link between electoral competition and policy extremism in the U.S. Congress. *American Politics Research*, *32*, 495-520.

Hilborn, R., & Mangel, M. (1997). *The ecological detective: Confronting models with data.* Princeton, NJ: Princeton University Press.

Hillygus, D. S. (2005). Campaign effects and the dynamic of turnout intention in election 2000. *Journal of Politics*, *67*, 50-68.

Holbrook, T. H. (1996). *Do campaigns matter?* Thousand Oaks, CA: SAGE.

Huckfeldt, R. (1979). Political participation and the neighborhood social context. *American Journal of Political Science*, *23*, 579-592.

Huckfeldt, R., & Sprague, J. (1995). *Citizens, politics, and social communication: Information and influence in an election campaign.* Cambridge, NY: Cambridge University Press.

Huntington, S. (1950). A revised theory of American party politics. *American Political Science Review*, *44*, 669-677.

Iyengar, S., & Petrocik, J. (2000). 'Basic rule' voting: Impact of campaigns on party- and approval-based voting. In J. A. Thurber, C. J. Nelson, & D. A. Dulio (Eds.), *Crowded airways: Campaign advertising in elections* (pp. 113-184). Washington, DC: Brookings Institution Press.

Johnson, P. E. (1999). Simulation modeling in political science. *American Behavioral Scientist*, *42*, 1509-1530.

Katz, E., & Lazarsfeld, P. F. (2005). *Personal influence: The part played by people in the flow of mass communications.* Piscataway, NJ: Transaction.

Keller, E., & Berry, J. (2003). *The influentials: One American in ten tells the other nine how to vote, where to eat, and what to buy.* New York, NY: Free Press.

Key, V. O. (1942). *Politics, parties, and pressure groups.* New York, NY: Thomas Y. Crowell Company.

Key, V. O. (1949/1984). *Southern politics in state and nation* (a new edition). Knoxville: The University of Tennessee Press.

Kollman, K., Miller, J. H., & Page, S. E. (1992). *Computational models in political economy.* Cambridge, MA: MIT Press.

Lazarsfeld, P. F., Berelson, B., & Gaudet, H. (1944). *The people's choice: How the voter makes up his mind in a presidential campaign.* New York, NY: Duell, Sloan and Pearce.

Lustick, I. S., Miodownik, D., & Jeidelson, R. (2004). "Secessionism in multicultural states: Does sharing power prevent or encourage it?" *American Political Science Review*, 98, 209-29.

MacRae, D., Jr. (1952). The relation between roll-call votes and constituencies in the Massachusetts House of Representatives. *American Political Science Review*, *57*, 1046-1055.

Massey, D., & Denton, N. (1998). *American apartheid: Segregation and the making of the underclass.* Cambridge, MA: Harvard University Press.

McElreath, R., & Boyd, R. (2007). *Mathematical models of social evolution: A guide for the perplexed.* Chicago, IL: University of Chicago Press.

Miller, W. E. (1970). Majority rule and the representative system of government. In E. Allardt & S. Rokkan (Eds.), *Mass politics.* New York, NY: Free Press.

Miller, J., & Page, S. (2007). *Complex adaptive systems: An introduction to computational models of social life.* Princeton, NJ: Princeton University Press.

Miodownik, D., & Cartrite, B. (2006). Demarking political space: Territoriality and the ethnoregional party family. *Nationalism and Ethnic Politics*, *12*, 3-82.

Mutz, D. C., & Mondak, J. J. (2006). The workplace as a context for cross-cutting political discourse. *Journal of Politics*, *68*, 140-155.

Nickerson, D. W, Friedrichs, R. D., & King, D. C. (2006). Partisan mobilization campaigns in the field: Results from a Statewide Turnout Experiments in Michigan. *Political Research Quarterly*, *59*, 85-97.

Niven, D. (2004). The mobilization solution? Face-to-face contact and voter turnout in a municipal election. *The Journal of Politics*, *66*, 869-884.

Oliver, J. E. (2001). *Democracy in suburbia.* Princeton, NJ: Princeton University Press.

Page, B. I., & Shapiro, R. Y. (1992). *The rational public. Fifty years of trends in Americans' policy preferences.* Chicago, IL: University of Chicago Press.

Platow, M., Mills, D., & Morrison, D. (2000). The effects of social context, source fairness, and perceived self-source similarity on social influence. *European Journal of Social Psychology*, *30*, 69-81.

Putnam, R. D. (2000). *Bowling alone: The collapse and revival of American community.* New York, NY: Simon and Schuster.

Rosenstone, S. J., & Hansen, J. M. (1993). *Mobilization, participation and democracy in America.* New York, NY: Macmillan.

Schattschneider, E. E. (1942). *Party government.* New York, NY: Holt, Rinehart and Winston.

Shaw, D., De La Garza, R., & Lee, J. (2000). Examining Latino turnout in 1996: A three-state validated survey approach. *American Journal of Political Science*, *44*, 338-346.

Shaw, D. R. (2006). *The race to 270: The electoral college and the campaign strategies of 2000 and 2004.* Chicago, IL: The University of Chicago Press.

Sniderman, P. M., Brody, R. A., & Tetlock, P. E. (1993). *Reasoning and choice: Explorations in political psychology.* New York, NY: Cambridge University Press.

Stimson, J. A., Mackuen, M. B., & Erikson, R. S. (1995). Dynamic representation. *The American Political Science Review*, *89*, 543-565.

Tam Cho, W. K., Gimpel, J. G., & Dyck, J. J. (2006). Residential concentration, political socialization, and voter turnout. *Journal of Politics*, *68*, 156-167.

Verba, S., Schlozman, K. L., & Brady, H. (1995). *Voice and equality: Civic voluntarism in American politics.* Cambridge, MA: Harvard University Press.

Whicker, M. L., & Strickland, R. A. (1990). U.S. constitutional amendments, the ratification process, and public opinion: A computer simulation. *Simulation & Gaming*, *21*, 115-132.

Zaller, J. (1992). *The nature and origins of mass opinion.* New York, NY: Cambridge University Press.

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