News Media Environment, Selective Perception, and the Survival of Preference Diversity within Communication Networks

Abstract

There is a natural tension between the effects on public opinion of social networks and the mass media. It is widely believed that social networks tend to harmonize opinions within them, but the presence of media may accentuate diversity by inserting discordant messages. On the other hand, in a totalitarian state where the government controls the media, social networks may mitigate the homogenizing pressure of a regime's propaganda. The tendency of opinion to follow the "official line" may be mitigated because opponents of the government interact on a personal level and bolster one another's views.

This paper explores the dynamics of opinion adjustment taking into account the influences of social networks and the mass media. It develops a conceptual framework to integrate different components in the communication process. It presents an agent-based simulation model in which individual agents are embedded within networks of interpersonal communication, but they also have access to messages from widely disseminated mass media. The model offers us the opportunity to observe changes at three levels—within individuals, in social networks, and the entire society. We begin with a consideration of opinion dynamics when there are no mass media, and then proceed to compare the dynamics observed when there are diverse media messages with those obtained when agents are allowed to access only a monolithic (state controlled) media that broadcasts a single, consistent message. We also explore the impact of two competing models of individual interpretation of messages obtained from the media. The results indicate that the overall impact of the introduction of the mass media is contingent on the diversity of the messages offered by the media as well as the willingness of agents to accept media messages at face value.

Keywords: communication networks, preference, diversity, media, selective perception, agent-based modeling

Introduction

Many students of political communication have contended that communication networks tend to homogenize preferences of their members. The longstanding view had been that social networks are almost completely homogeneous, rendering interpersonal communication a somewhat hollow exercise in re-affirmation of shared opinions (e.g. AXELROD 1997b; LAZARSFELD ET AL. 1968). That extreme view has been somewhat muted by recent work, but there is still a general tendency to believe that opinion networks collect together like-minded people and encourage conformity (e.g. MUTZ and MARTIN 2001). Some recent empirical research indicates that there are higher-than-expected levels of preference diversity among people who regularly interact (e.g. BAKER ET AL. 2006; HUCKFELDT ET AL. 2002; ZUCKERMAN ET AL. 1998), causing a re-formulation of our theories about the role of social networks in opinion formation.

There is an emerging consensus for the view that individual opinions reflect a complicated mixture of influences, including interpersonal interactions over a period of time and ideas and messages gathered from the mass media. Whereas individual interactions are, by definition, confined to the small spaces of social networks, the distinguishing characteristic of the media is that a single message may be consumed by many people simultaneously. One might suppose that the media will tend to wield an enormous impact on opinion, but, as we shall see, there are several personal and social network attributes that may mitigate media impact. The primary personal elements that mitigate media impact include the tendency of some to ignore the media altogether, the ability to discount media messages that contradict long-term personal experience, and the ability to sort through media s and particular messages to find components that support existing opinions. Equally important, however, there are the mitigating elements in social networks. Media messages may have "shock value" that impacts public opinion over the short term, but social interaction can often remind people of their long standing opinions and bolster people who are "on the verge" of changing their minds (HUCKFELDT ET AL. 2002, 2004).

The complexity of this process, involving variables at the individual, group, and social levels, makes the assessment of media impact difficult task for empirical research. One may predict that a democracy where the news media are polarized and all citizens sometime perform selective perception will grow more polarized and that preference diversity that an individual could perceive within his or her community will decrease. This validity of scenario may be sound but it is very difficult to examine with an empirical approach (see also SHIBANAI ET AL. 2001). This paper employs agent-based modeling (ABM) as a way to answer how (1) interacting with the news media and communication networks and (2) performing selective perception affect preference diversity. Is the existence of such polarized news media environment detrimental to the cultivation of a heterogeneous environment where individuals perceive a great level of preference diversity to make fair choices about an issue or a candidate? And, to what extent does selective perception performed by the audience influences this process? To understand the effect of polarized media sources on a controversial issue, we need to

contract a system with multiple news sources against a system of no news media and a system where there is only one news source. Plus, we also need to consider how the audience perceive and process information they obtain from the news.

Next section will provide an overview about media and communication network effects, empirical findings that validate our model design. The third section will describe the design of the simulation and the strategy of using five models to answer our questions. We present the results with summary statistics, visualized patterns, and time-series graphs in the fourth section with discussion of the findings in the last section.

The Interplay of Communication Networks and the News Media

The view that social networks are homogeneous and self-reinforcing traces back to the early research on public opinion that is known as the Columbia School (BERELSON ET AL. 1954; KATZ and LAZARSFELD 1968; LAZARSFELD ET AL. 1944; for a review, see CARMINES and HUCKFELDT 1996). The view that people are inclined to talk to like-minded others and vote for a candidate that is supported by the majority of the group members has inspired much follow-up research in the United States (e.g. BECK 1991; HUCKFELDT ET AL. 2002; MUTZ 2001; ROCH ET AL. 2000; SCHERER and CHO 2003; WYATT ET AL. 2000) and Great Britain (PATTIE and JOHNSTON 2001, 2002). Perhaps the original contention that social networks are homogeneous was an over-exaggeration, but there is nonetheless a considerable amount of truth in the idea that networks tend to exert a homogenizing influence.

The empirical research suggests that the homogenizing influence of social networks often stops short of eliminating preference diversity. Instead, there are several factors that sustain preference diversity within networks. People who are in the minority in one social context are often able to find people of similar perspective in other contexts. Interaction with self-selected network members, especially when new information is obtained from trustworthy others, may cause opinion change, but it can also bolster existing opinions (HUCKFELDT ET AL. 1995; LAKE and HUCKFELDT 1998). Social networks tend to be highly idiosyncratic and non-overlapping. It is not typically the case that people who talk to each other form a closed circle that excludes all others. Rather, it is more likely the case that each individual person constructs a list of discussants, and the lists held by several people who interact do not coincide to a large degree. In other words, even if two people interact with each other, it is not likely that they share the same discussants. As a result, people who hold views that are unpopular in one setting sometimes find support from other members of their personal networks who hold similarly unpopular views (BECK ET AL. 2002; HUCKFELDT ET AL. 2002; HUCKFELDT and MENDEZ 2004). There is also evidence for the view that individuals are not necessarily adverse to political disagreement. People seem to seek out others that they consider to be experts—those with greater level of political knowledge—even though they do not agree with those experts (CARMINES and HUCKFELDT 1996; HUCKFELDT 2001; MILLER and KROSNICK 2000).

On the surface, it seems as though the mass media might exert a powerful homogenizing force on public opinion because a single message is disseminated across society, touching individuals across a variety of social networks. Early research which sought to quantify the impact of the media left researchers disappointed because the impact seemed to be rather "minimal" (BARTELS 1993; CONVERSE 1964a). Recent findings point out that the influence of mass media on the public is conditional. Psychological mechanisms such as selective exposure, selective perception, and selective retention (KLAPPER 1960; MUTZ 1998) may be a part of the explanation for the minimal effects. People s that coincide with their current views (e.g. MUTZ and MARTIN 2001). The uses and gratification theory emphasizes that individuals use the media to strengthen their existing preferences (MCLEOD ET AL. 2002; RUBIN 2002). When discordant media messages arise, people use their current beliefs to judge the credibility of a media source and often misremember messages that run counter to their pre-existing beliefs (OLIVER 2002). Where news sources, such as radio talk shows, take a one-sided approach to a controversial issue, the mechanism of selective perception drives individuals to be more radical in their preferences (HOLBERT 2004; JONES 2002).

In this research project, we are interested in integrating our understanding of social networks and the mass media to assess the extent to which the mass media and social networks homogenize the public. The "minimal effects" results should not lead to the conclusion that the media are unimportant, any more than the Columbia School findings indicate that social networks are irrelevant. Rather, we see that both sets of findings point to the fact that individual opinions reflect a complicated mixture of personal experience, interpersonal communication, and exposure to the mass media. The media message can bolster an individual's opinion, and if that individual is in the minority within a given family or workplace, then the media play an important role in mitigating the homogenizing pressure of interpersonal interaction. The media may not have the impact of observably changing an opinion, but it is important nonetheless.

We also acknowledge the importance of individual difference, the fact that individuals differ in the way they interact with information sources, such as the frequency of accessing the news media, involvement in political discussion, and the likelihood of performing selective perception. A finding that political knowledge facilitates the process of incorporating new policy-specific information into political judgments (GILENS 2001), which confirms a classic distinction between the politically aware and the politically less aware (CONVERSE 1964b; FIORINA ET AL. 2005), further suggests that there exists a certain proportion of individuals that are more capable of processing political news and making sense of the pieces of information than the politically unaware majority. Because party identification and the media news consumption reinforce each other, the politically aware will be more able to resist information from the news media.

In sum, the literature suggests that preference diversity survives when social support is available within one's communication networks and/or when individuals, particularly the politically aware, perform selective perception of political news. Unfortunately, empirical studies that attempt to distinguish media effects from communication networks is not entirely satisfying. As Mutz (1998) contends, the influence of personal interaction on

opinion is implicit (see also SHANE 2001). Huckfeldt et al. (2004) also suggest that, because network effects are dynamic and subtle, it may be that empirical research will not resolve the problem to the satisfaction of all.

In this article, we intend to show that it is possible to use a series of computational simulation to make some headway on a theoretical level (see also GONZALEZ-AVELLA ET AL. 2006; SHIBANAI ET AL. 2001). Taking into account the insights gained from previous empirical research, we propose a self-organizing computer program that take into account the nature of communication networks and important factors of information processing.

Previous Models of Opinion Dynamics

Students of public opinion were among the first social scientists to introduce agent-based models. Many of the core ideas of simple cellular automata found direct applications to opinion models that represented spatially-arrayed agents colored squares in a grid of cells. The social impact model (LATANE 1981; LATANE ET AL. 1994; LATANE and NOWAK 1997; NOWAK ET AL. 1990), a leading application of the cellular automata, describes a situation in which each agent is simultaneously pressured by all of the rest. Agents that are close together exert a stronger influence on each other than agents who are far apart, and cells change value when the pressure in favor of change exceeds the pressure opposed to it.

One of the major shortcomings of the social impact model is that it does not describe inter-agent communications in any detail. The distance-based formula for social pressure is assumed, rather than derived within the framework of the model. The agents do not interact on a one-to-one basis. That is certainly not the case in other early opinion models, where individual interactions are allowed and they drive the development of the system. Building on Carley (1991), Axelrod's (1997b) highly influential "culture model" (referred to as the ACM) described agents on a grid who select each other for interactions and copy traits from one another. Although it has not always been clear in discussions of the ACM, that model always evolves into a social system evolves into rigidly separated blocks, where the agents within each block are completely identical and agents from neighboring blocks are completely different from each other (HUCKFELDT ET AL. 2004). In many simulations, the end result is a homogeneous society.

The ACM has been the basic framework in which many variations have been considered. The arguments offered, however, should be qualified in light of the fact that the ACM tends to homogenize the society, so changes that are introduced have to be interpreted in that light. Two projects have introduced mass communication elements in the reconsideration of the ACM. Shibanai et al. (2001) provide agents with a globally accessible information source—the news media—that informs them about the state of the society. When a plural information mechanism is assumed, global information distributed through the mass media may maintain local diversity. Using the terminology of statistical physics, Gonzalez-Avella et al. (2006) represent the ACM as an Ising spin glass and

introduce message sources that are available across several cells. When the individual probability of accessing the news media is sufficiently large, the mass media will contribute to cultural diversity. The media source, hence, acts as a "fifth neighbor" that thwarts the homogenizing tendencies of social networks. The authors note the irony of this finding: the insertion of an effect that is common across cells tends to diversify the cells. But one should not forget that the result is specific to the ACM, a model that has a very particular dynamic that does not match our expectations in the study of public opinion.

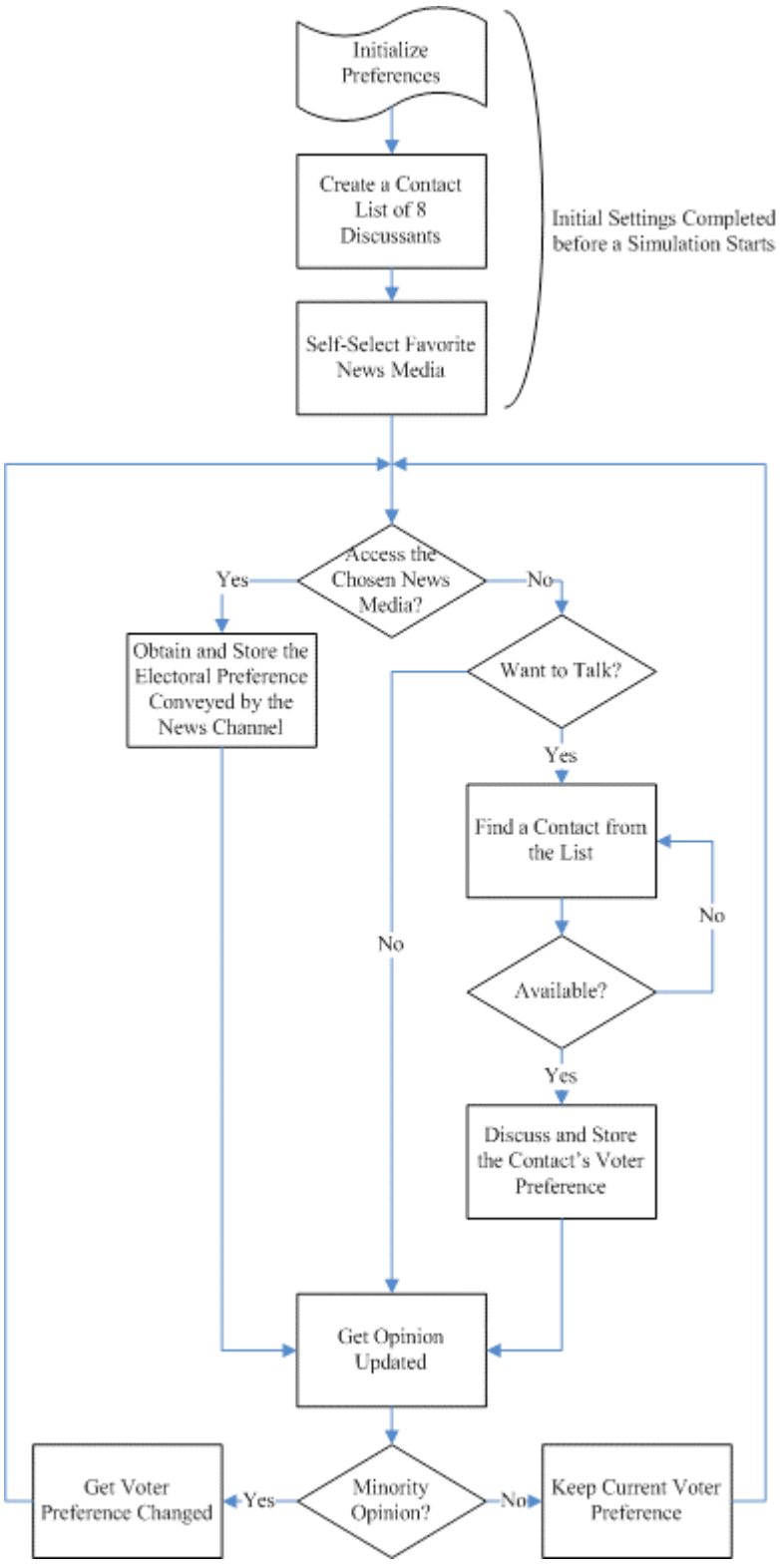
Also from a physicist's perspective, Galam (1997) presents a grid-based model to represent agents who make "yes" or "no" decisions. Preference diversity may emerge when the model introduces individual differences, such as "cultural values, past experiences, ethics and beliefs." The authors claim that individuality is "a necessary ingredient to both weaken extreme option and oppose an external social pressure" (p.79). The introduction of agents that are impervious to social interaction may prevent the homogenization of opinion, but we doubt that it is a necessary component. Quite the contrary, a richer model of information evaluation seems to both prevent the homogenization of opinion and generate a more empirically accurate prediction about opinion dynamics. Huckfeldt, Johnson, and Sprague (2004) develop a model in which agents accumulate opinions from various agents and then adopt new views when there is substantial support for those views in their personal networks. Galam (2005a; 2005b) proposes a similar strategy, one in which agents respond to pressure from their neighbors only when certain supports for the current point of view are lacking. Galam (2005a) suggests, as do Huckfeldt, Johnson, and Sprague, that the extension of the model to include media effects would be quite welcome.

We propose to extend the analysis of these projects by building a richer model of social interaction and then introducing mass media components. Our social network model is based on the view that persuasive information primarily comes from family and like-minded friends with whom people interact, but divergent views may be encountered on a regular basis.

Model Design

We construct an agent-based model to simulate the long-term influence of political interaction in conjunction with selective perception of media messages. Agent-based modeling (ABM) has been increasingly widely used in the social sciences (AXELROD 1997a; JOHNSON 1999) and studies of opinion formation have been particularly widely used (e.g. AXELROD 1997b; CARLEY 1991; HEGSELMANN and KRAUSE 2002; HUCKFELDT and MENDEZ 2004; LATANE 1981; LATANE and NOWAK 1997; NOWAK ET AL. 1990). In our model, the term agent will refer to citizens who are evaluating information (for example, they might be thought of as voters during an election campaign). The agents follow behavioral rules and we observe the impact over time of their dyadic interactions. Our computer code makes use of the Swarm Simulation libraries (http://www.swarm.org).

Figure 1: The Flow Chart of Agent Information Processing



The goal of ABM design is not to mirror the real world perfectly, but create a reasonably realistic framework that characterizes the essential features of the problem that we are studying. This approach represents self-contained information processing agents who interact according to a variety of possible behavioral rules. Unlike reality, which frustrates our efforts to isolate media and network effects, the simulation framework offers an opportunity to use an "artificial society" to measure the impact of hypothesized conditions on phenomena of interest (EPSTEIN and AXTELL 1996). A flow chart that describes how agents in our model process information and update their preferences is presented in Figure 1.

The Features of Agents

We consider a model in which there is one issue, which might represent the choice of candidates in an election (Bush or Kerry in the 2004 American presidential election, for example) or a "Yes" or "No" decision on a referendum. We abstract this by simply referring to two values, 1 (or "Yes") and 0 (or "No"). A two valued piece of information is called a "bit". At the outset, each agent has randomly assigned opinion, either 0 or 1. This means that, in each simulation, the initial conditions present us with an approximately evenly divided society.

Each agent has a "political memory", a string of bits that represents the agent's experience. Each element represents an impression, scored either 0 or 1, to summarize perceptions about the position of a discussant or the news media. Agents do not keep comprehensive records on what particular agents "say," or which agent contributed a particular opinion. They simply formulate Yes or No impressions and add them onto the string of bits in memory. This approach has been proposed in several studies (PETTY and CACIOPPO 1981; ZALLER 1992).

The memory strings of the agents can be used to summarize the state of the society. The memory string of an agent who encounters only "No" opinions would look like this: (0,0,0,...,0), while that of an agent who encounters only "Yes" would be (1,1,1,...,1). If a society is composed of agents like that, then we say it is highly polarized, in the sense that the experiences of randomly drawn agents are likely to be either completely different or exactly the same. On the other hand, in a society where agents encounter a mixture of opinions, memory strings would have more variety. If we calculate the average of these bits, we arrive at a numerical index that can be displayed in the model's graphical interface.

Every agent is unique and autonomous in its behavior. There are six fixed parameters that are set for each agent at the beginning of the simulation: party identification, political expertise, capacity of memory, the probability of discussing politics, the probability of accessing the news media, and the probability of performing selective perception (.1 to .9).

We have endeavored to represent a "two step" information flow in this model by creating agents from two different classes. While all agents may obtain information from the media, it is most likely that information will be gathered by an elite group of "politically aware" agents who then disseminate information to the other agents through personal discussion (Elihu Katz 1957; LIU 2007). A "politically aware" agent is one that has a longer memory (20 bits are remembered), higher expertise (drawn at random from 6, 7, 8, 9, 10), a higher propensity to access the news media (equally likely between .6 and .9), and a high propensity to discuss politics (between .6 and .9).

We set that most agents—98 percent of the population—are not politically aware. The "masses" have shorter memories (10 bits), lower political expertise (drawn at random from 1, 2, 3, 4, 5), and lower probabilities of discussing politics, accessing the media, and exercising selective perception (all parameters drawn at random from the interval between .1 and .5). By this design, a politically less aware agent is less likely to initiate a political interaction and is also less likely to be the target of an interaction initiated by another who is seeking political expertise.

Agents who perform selective perception will interpret what they receive from the news media (either 0 or 1) to be consistent with their belief system. When agents do not perform selective perception they will ignore messages from the media, or store nothing in memory, when they access the news media at a given iteration. We assume that the politically aware, compared to the less politically aware, are more likely to selectively perceive and reinterpret messages from the news media consistent to their belief system. Therefore, we set that individual citizen agents favoring 1 (or saying "Yes") are more likely to store 1 in memory every time they access the chosen news object; agents favoring 0 (or saying "No") are more likely to receive 0 every time they access the news media. If we take one more step to take into account the mechanism of selective perception mentioned above, in our model politically aware agents that favor 1 are more likely to receive 1 every time they access the news media than are the politically unaware that are also favoring 1. Similarly, for agents favoring 0, the politically aware are more likely to receive 0 every time it access the news media than are the politically unaware that are also favoring 0. For example, a politically aware agent is created with the value of its partisanship set to 1 and the value of selective perception initiated .6. When the agent accesses its favorite news media (should be the media that favor 1), it will have an odd .6 to save 1 in its running tally of memory. Four out of ten times when the agent chooses to access the news source it will not perform selective perception, which means that it will store neither 0 nor 1 in its running tally.

How Opinions Change

The agents will retain their opinion unless a substantial amount of evidence accumulates in favor of the other side's point of view. Recall that this is a central element in the autoregressive influence model (HUCKFELDT and MENDEZ 2004) and the theory of spiral of silence (NOELLE-NEUMANN 1993). It is somewhat difficult to know for sure exactly how much evidence should be required before an agent will change its mind. In

the model we propose here, the politically aware agents remember the 20 most recent interactions, the politically less aware remember the 10 most recent interactions, and we require that half of them must favor the opposing point of view before the agent changes its opinion.

Dyadic Interaction within a Communication Network

All interaction among agents is dyadic in nature. There are no "group discussions." Rather, agents search for like-minded others with whom to interact. Agents look for discussants based on their contact lists where the priority is an agent with a higher level of political expertise and the same party identification. When an agent finds an available discussant, both agents will become unavailable to the other agents (see HUCKFELDT and SPRAGUE 1995).

Regarding the design of communication networks and "contact lists," the agents are evenly distributed on a 3x3 square grid. Every agent is surrounded by eight possible contacts. Each agent's political party identification and political expertise is clearly visible to its contacts. An agent will decide to initiate a political interaction with a given probability, and then the agent will seek out a discussion partner. Agents can only initiate discussion with another if that other agent is not already having a discussion with someone else. The agent's search process will proceed in two steps. First, the contacts that share the agent's political party identification are considered. They are sorted by political expertise and the available agent with the most expertise is invited to interact. Party identification is the first criterion of contact selection, while political expertise comes as the second. The most favorable contacts are those with the same political identification and of higher political expertise. The less favorable contacts are those with different party identification but higher political expertise. The least favorable agents are those with different identification and lower political expertise. The particular contacts with whom any agent will interact is thus somewhat unpredictable.

Although the agents in this model are described as residing in a grid, we do not mean to say that we believe social interaction is strictly based on geographical distance (as would, for example, NOWAK ET AL. 1994). Rather, we see that the eight possible contacts might be located in a diverse set of geographical positions. For example, suppose that Mary's parents like to discuss politics with her, but she prefers discussing politics with her like-minded boy friend that lives in another town, with two close friends in her American politics class, and with three friends online.

Integration of the News Media

We construct the news media object as an object, external to an agent's communication network, that broadcasts "the sequence of the most preferred features, to be referred by the target agents equally," (SHIBANAI ET AL. 2001, p.84) such as "advertising or propaganda being imposed by controlled media on all elements of a social system"

(GONZALEZ-AVELLA ET AL. 2006, p. 46119-3). Unlike communication networks where an individual interacts with limited number of people, a news media object can be seen as any source of information other than dyadic interpersonal discussion. Because by design every agent will have an equal opportunity to access self-selected news media objects and because the news media object is subjectively chosen, an agent will receive preferences that are consistent with the agent's belief system. Similar to what Shibanai et al. (2001) describe in their first experiment, news media objects we described above can be seen as the 9th network member (in addition to the 8 self-selected discussants in a Moore neighborhood) of an agent and the top of the agent's contact list.

Salient issues, especially controversial ones, such as abortion, gay rights, and tax cut, usually lead to polarization in the public. The attitudes of the news media regarding these issues—supporting or opposing an issue, or holding conservative or liberal tone about the issue˜ are usually explicitly and implicitly revealed in their programs, the choice of sound bites or events, talk shows, etc (e.g. IYENGAR and HAHN 2007). To be consistent with this empirical pattern, we construct two news media objects in our model indicating two streams of "global information," each of which can be understood as a TV channel, a newspaper, a radio program, a magazine, a news website on the Internet, or even a town hall meeting. These characteristics of the news media in our model, therefore, lie in the assumption performing selective perception is a matter of degree when individuals access the news media.

The Experiment Design

Given a model of artificial soceity described above, we use five sets of parameter values to explore (1) the extent to which the influence of media use differs from the influence of communication networks and (2) the influence of selective perception on preserving preference diversity within communication networks.

Other things being equal, Experiment 1 (No Media) has no news media object (the value for the parameter numMedia is set to 0) so that interaction with their communication networks is the only way in which agents obtain political information. Experiment 2 (Two Media Objects & Agents Performing Selective Perception) has two news media objects, one favoring 1 and the other favoring 0 (the value for the parameter numMedia is set to 2). and allows all agents to perform selective perception. Experiment 3 (Two Media Objects & Agents Performing No Selective Perception) keeps the setting of Set 2 but turns off the mechanism of selective perception.

Initial conditions are controlled so that the i'th run of each model is confronted with an identical set of initial conditions. As a result, any differences observed across the models on the i'th run are solely due to differences in the behavioral rules that are employed. Hence, it will be meaningful to make some fine-grained comparisons across the simulation results. With these first three experiments, net effect of communication networks can be shown through a comparison the results of Experiment 1 and the results

of Experiments 2 and 3. We will also see the net effect of selective perception mechanism by comparing the results of Experiment 2 and Experiment 3.

Next, in Experiments 4 (One Media Object and Agents Performing Selective Perception) and 5 (One Media Object & Agents Performing No Selective Perception) we replicate Experiments 2 and 3 except that we reset parameter values of numMedia to 1. The monotone news media object consistently favors 0 or "No".

We have collected batches of 100 runs for each of the 5 experiments. The simulation begins with randomly assigned conditions, such as the location of the two classes of agents, and stops when opinion patterns appear to have stabilized (20 passes are made through the list of agents without any preference change), or when the number of passes exceeds 900.

The starting points for each run within each batch are equivalent. That is to say, in the first run of each experiment, the same set of parameter values, such as information about voter preferences, party identification, and expertise is used. Each run for each experiment begins with approximately half (recall preferences are assigned randomly) of the 16,000 agents (including the two classes of the agents—the politically aware that account for 2% of the population and the less politically aware that account for the rest 98%) holding preference "1" and the other half holding "0." The aggregate indicators are:

1. The proportion of agents who hold vote preference 1 or "Yes." This indicator will suggest if the distribution of political preference will change over time.
2. The level of perceived diversity—a summary of the homogeneity of the agent environments. Agent experiences diversity if it has 2 or more opposing opinions in its memory at a given time. The aggregate indicator represents the proportion of agents who experience diversity.

Results

Having simulation run forever does not help understanding the dynamics of a short-term campaign period. Moreover, although 900 is an arbitrary number used to stop simulation, we found that the patterns of simulation exceeding 900 are not much different from those found at this time step.

The series of simulation lead to two major findings. First, an artificial society in which agents access no media or a monotone medium will form identifiable preference clusters. Second, the effect of selective perception is contingent upon the media environment. In an artificial society that has multiple news sources selective perception helps preserve preference diversity at the communication network level (Experiment 1). In an artificial society where agents access only one news source, however, selective perception demolishes such diversity (Experiment 4).

We present the findings statistically and visually. The differences between the five experiments are summarized in the upper part of Table 1. The summary statistics (mean and standard deviation) in the lower part of Table 1 shows the central tendency of the 100 runs for each experiment with respect to the proportion of agents supporting "Yes" and the proportion of agents perceiving preference diversity within their communication networks.

General Patterns

Table 1: Summary Statistics of the 100 Runs of Simulation for Each Experiment

Parameters	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5
Number of News Source	0	2	2	1	1
Agents Performing Selective Perception	-	Yes	No	Yes	No
	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)
Preference "Yes"	.507 (.051)	.501 (.052)	.501 (.036)	.007 (.004)	.501 (.055)
Preference Diversity	.214 (.015)	.232 (.014)	.335 (.012)	.009 (.005)	.232 (.013)

First, the small standard deviations across the board suggest that every experiment has small variance across their 100 runs. Since each run of the experiment (i.e. from the time step 0 to the time step 900) is initiated with a different random seeds, the 100 different random seeds generate 100 different results. Small standard deviations of the means prove that the patterns emerging from simulations will be insensitive to extreme situations.

Second, given the initial setting that about 50 percent of agents hold the preference 1 or "Yes" and the rest favoring 0 or "No," it is interesting to find that the proportion of agents supporting "Yes" remains almost unchanged in the first three experiments—.507, .501, and .501, respectively. As a clear contrast to the first three experiments, this proportion drops in Experiment 4 (.007). and Experiment 5 (.353). This finding suggests that, if the public is polarized between "Yes" and "No," the status of polarization is very likely to continue unless there is change in the news media environment, such as all news media take the same side of the issue (in the case of this paper, the media turn to support "No") or when there is only one state-owned media broadcasting a negative preference about the issue.

The seventh row of Table 1 reports the means of the proportion of agents perceiving preference diversity. The initial proportion of agents perceiving preference diversity is .5. Table 1 shows dramatic drop in Diversity across the five experiments: .214, .232, .335, .009, and .213, respectively.

The decline in Diversity suggests the formation of homogeneous networks. When the simulations end, agents reporting that they perceive preference diversity are those who reside in the "edge" of homogeneous networks. This proportion for Experiment 4 is .009, suggesting that there are only about 14 agents (out of 1,600) perceiving diversity. Such small amount of diversity survives, like the results of the counterpart experiments, should be in the form of opinion clusters. By design, only homogeneous networks prevent their members from being conformed to the majority preference.

A closer comparison across the five experiments suggests the important roles of the number of news media source and selective perception in terms of surviving preference diversity. First, the increase of diversity from 23.2% (Experiment 2) to 33.5% (Experiment 3) suggests that, given two news media sources, when agents, particularly the politically aware agents, stop interpreting news media information to their side, the level of preference diversity increases at the aggregate level. Although the politically aware, by design, account for only 2% of the population, they are likely to become nodes of influence or the center of preference clusters.

A further comparison between Experiment 4 and Experiment 5 suggests a similar pattern. As Experiment 4 shows, the single source of news media broadcasting 0 or "No" successfully reshapes and homogenizes the public's preference. If agents, particularly the politically aware, stop performing selective perception, diversity level will increases from 1% to 21.3%, the level close to that of Experiment 1 and Experiment 2.

Visualized Patterns

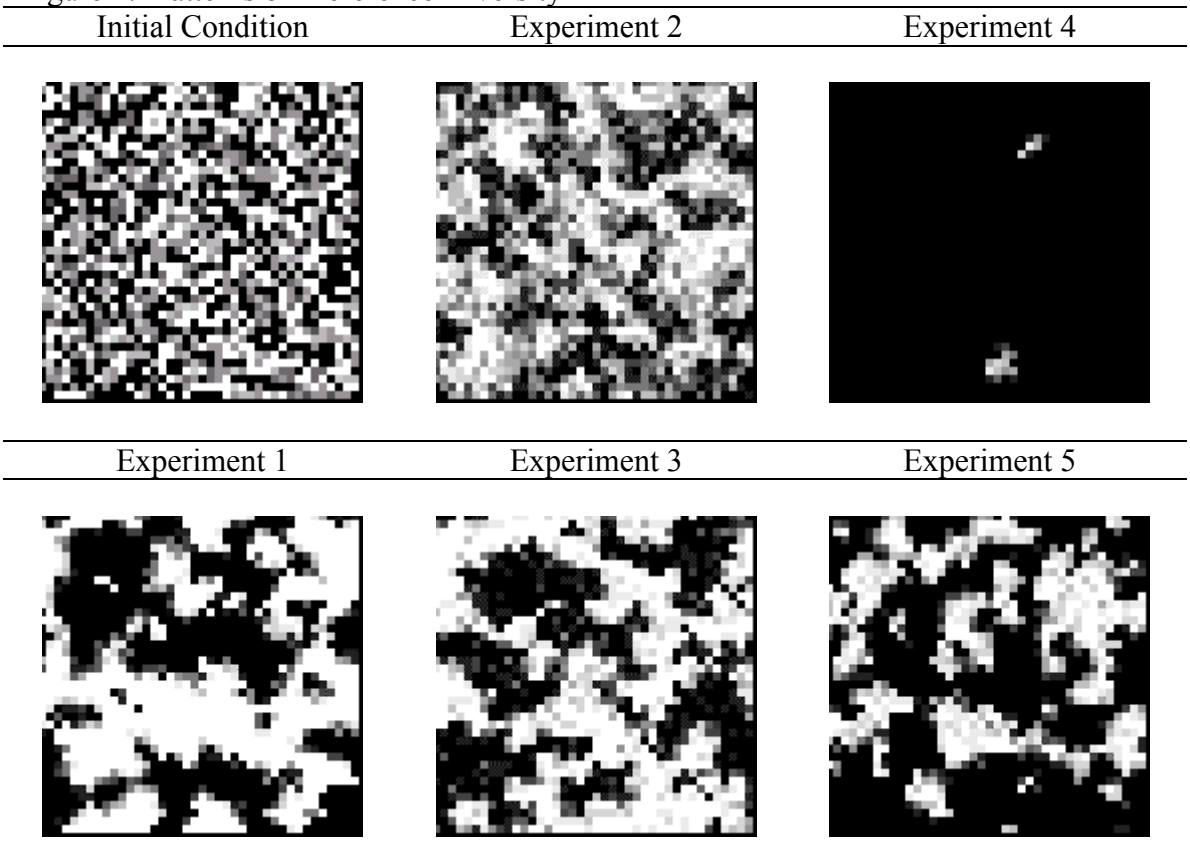
The pictures shown in Figure 2 confirm those derived from Table 1 and provide more information about the influence of the number of media sources and the influence of selective perception on the distribution of disagreement.

The initial condition (the upper left of Figure 2), based on the assumption that individuals have a preexisting preference guided by their party identification, randomly distributed agents holding a preference. About half of the agents hold 1 or "Yes" (white) and the rest hold 0 or "No" (black). By design, the cells do not simply show voter preference in white and black but show opinion that varies between 0 and 1. Hence, Figure 2 better than a figure simply showing agent's voter preference to presents the distribution of ambivalent agents (in gray). Because individual agents will start to collect impressions from either the news media or their network members and update their opinions based on the average of the past preferences, gray cells will emerge when a simulation starts. Gray cells will indicate the locations of agents experiencing diversity or ambivalence.

The visualized pattern of Experiment 1 shows that interaction with network members at the local level creates opinion clusters at the aggregate level. There is little diversity found within the clusters, which suggest that these clusters homogenize the preferences of their members.

The pictures of Experiments 2 and 3 in the middle column of Figure 2 show the net effect of selective perception. One sees that Experiment 2 has greater variance in opinion within communication networks and that Experiment 3 shows clear edges of opinion clusters (even though the variance of opinion is greater in Experiment 3 than in Experiment 1. This suggests that, although polarized news sources sustain the polarization of vote preferences, agents in Experiment 2 perceive greater diversity in their communication networks than their counterparts in Experiment 3, even though the averages of the number of agents perceiving diversity in both experiments (as shown in Table 1) are similar. This pattern implies that in a society with multiple news sources the mechanism of selective perception at the individual level is likely to contribute to the survival of preference diversity at the network level. If the individuals in this society turn to ignore political information about the given issue every time when they access the news media, the number of individuals perceiving diversity will increases (as the means in Table 1 suggest), but opinion clusters will grow more homogeneous.

Figure 2: Patterns of Preference Diversity



Note: The snapshots were taken at the 900th time step (update). Except that Experiment 4 converges at the 461st time step, all of the experiments continue updating over 4,000 time steps, meaning that in at any 20 consecutive time steps there exists at least one agent changing its voter preference. Each experiment runs for 100 times with different seeds, so each experiment results in 100 pictures of the opinion raster taken when the simulation stops. Presented pictures are obtained from the runs which yield the means of the two

parameters (OpinionYES and Diversity) that are closest to the means of two variables averaged from the 100 runs (as shown in Table 1). Specifically, for the 100 simulations of each experiment, Figure 2 presents the 85th run (seed 3850763) for Experiment 1, the 21st run (seed 908381) for Experiment 2, the 46th run (seed 2232645) for Experiment 3, the 55th run (seed 2566711) for Experiment 4, and the 75th run (seed 3396126) for Experiment 5. These run numbers and specific seeds recorded here will help future researchers to use our model to replicate the presented results.

The mechanism of selective perception has a different role when the news media environment is changed. When all news sources broadcasting the same preference, or when there is only one news source, it will be difficult to see a balance between the two vote preferences. Public opinion will be drawn toward the side that the news medium favors. As Experiment 4 shows, the opinion raster becomes dark society-wide quickly and this pattern remains stable (the pattern converges within 461 time steps, including 20 consecutive time steps when no agent change its preference). The 50 percent of agents favoring 1 or "Yes" in the beginning of the simulation apparently cannot persist against influence of their discussants who consistently get "brain-washed" through selectively reinterpreting or trusting what the medium suggests (0 or "No") on the given issue. This pattern further implies that the selective perception mechanism conducted by the audience can be an invisible helper for a regime to reshape public opinion in a short time. Preference diversity or political disagreement in this homogeneous environment may survive, but this will occur only if dissidents can meet and continue to interact with each other.

This pattern of homogeneity can be changed in three possible situations. First, the news medium itself starts to provide diverse perspectives on the given issue. Second, the regime or the society opens the market to other news sources. These two situations will transform the pattern of Experiment 4 to one that similar to the pattern of Experiment 2.
The third situation is that the audience of that society changes the way they see the single news source. Given that everything is controlled, when individuals start to ignore what they receive from the news source on the controversial issue (due to either cynicism or distrust to the government), preference diversity survives and clusters of the opposite preference emerge. In Experiment 3, 70 percent of agents that favor 1 or "Yes" in the first place find support from their communication networks or from larger opinion clusters. The pattern of Experiment 5 can grow to one that is similar to the patter of Experiment 3.
The Dynamics of Preference Changes

Figure 3: The Flow Chart of Average Proportion of Agents Favoring "Yes"

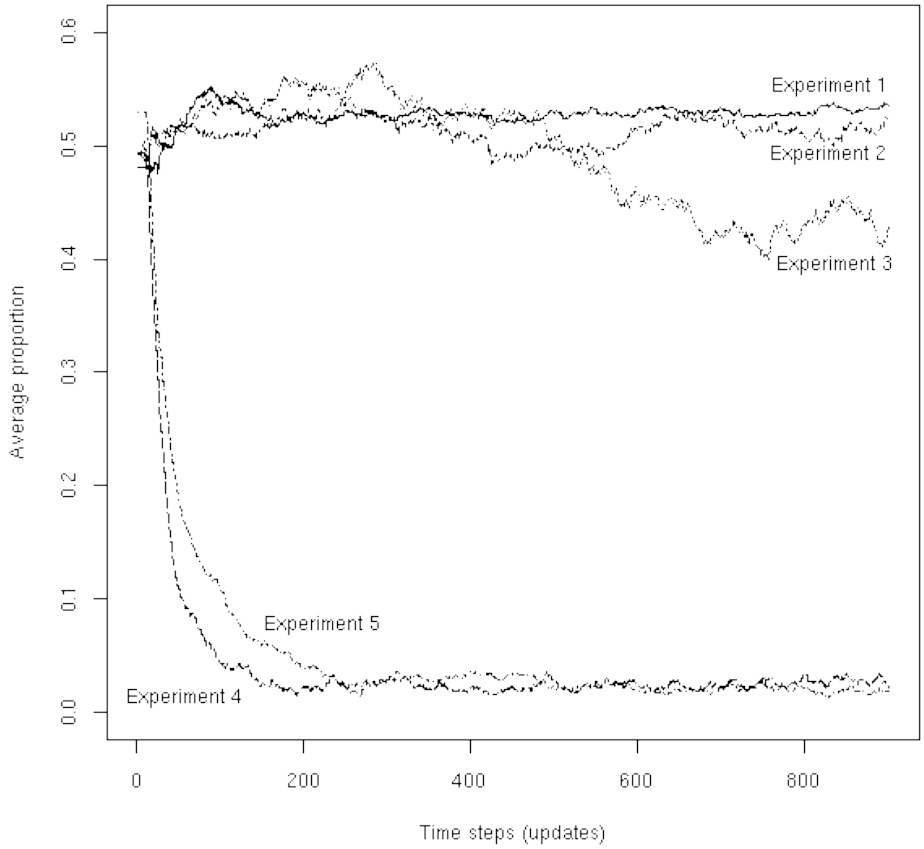
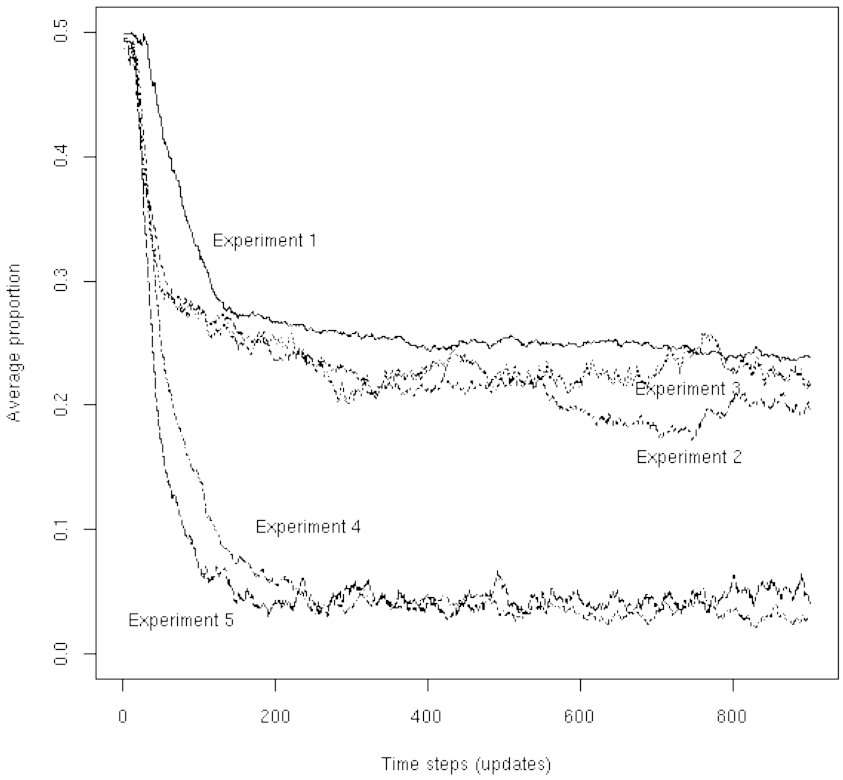


Figure 4: Average Proportion of Agents Perceiving Diversity



The time-series curves in Figures 3 and 4 give supplemental information to the patterns described above. Figure 3 compares the five experiments regarding the proportion of agents favoring "Yes," while Figure 4 compares the five experiments regarding the proportion of agents perceiving diversity. Three more observations can be drawn from these graphs. First, the preference curve of Experiment 1 remains stable but its diversity curve drops dramatically in the first 200 time steps. This helps describe how opinion clusters form in a short period. Second, the preference curve and the diversity curve of Experiment 4 drop even sooner than those of Experiment 1. This presents how influential the synthesis of a monotone media environment and communication networks on the homogenization of the public's preference. Third, in both figures, both curses of Experiment 2 have the greatest dynamics among the five experiments. This implies that it is difficult to capturing the "accurate" public preference about the given issue capture in a society that Experiment 2 represents. The timing of polling or survey matters; polling or surveys of the agents conducted at different time step will find inconsistent results.

Conclusion and Discussion

In the present study, we have shown how diverse news sources and the mechanism of selective perception affect the survival of preference diversity. The results indicate that the overall impact of the introduction of the news media is contingent on the diversity of the messages offered by the media as well as the willingness of agents to accept media messages at face value.

By design, political discussion within communication networks is a force to homogenize individuals' preferences. This pattern corresponds to the three robust features of social self-organization: clustering, consolidation, and continuous diversity (LATANE ET AL. 1994; LATANE and NOWAK 1997). Moreover, the comparison across the simulation results suggests that—given the availability of multiple news sources and an assumption that individuals consistently access their favorite news s and sometime perform selective perception of the news—preference diversity can survive in networks composed of like-minded individuals. These findings are consistent with the view that accessing the news media is a force of enhancing social heterogeneity (GONZALEZ-AVELLA ET AL. 2006; MUTZ and MARTIN 2001; SHIBANAI ET AL. 2001).

The findings of this paper advances what we have known by two points. First, increasing probability of interacting with the news media may not necessarily lead to preference diversity. We suggest that accessing the news media sustains preference diversity is contingent upon whether individuals have freedom to access self-selected news sources. Regarding the survival of preference diversity, there exists a discernible difference between a society with multiple news sources and a society only having state-own news media (or a society with multiple news sources but all favoring one side of an issue). Second, selective perception of news media messages as a mechanism of processing information plays a critical role in the survival of preference diversity. Correspondent to an empirical finding that selectively accessing fragmented media environment increases the likelihood that viewers strengthen their partisanship and ideology (JONES 2002), our finding further shows that, in a multiple-source news environment the number of individuals who perceive preference diversity is likely to drop if the assumption of selective perception holds. In a situation where all of the individuals ignore what they receive from the news media or simply refuse to take these piece of information seriously the number of individuals perceiving preference diversity is likely to increase and the boundaries of opinion clusters is likely to become distinctive. This implies that when individuals in a society become more selective in the source of news, or even prone to reinterpret messages to support their existing (biased) beliefs, the society might grow more polarized (as shown in the comparison between Experiment 2 and Experiment 3 in Figure 2. This finding also implies that, if a society has grown polarized, one way to mitigate it is to decrease opportunities that drive individuals to "bowling along" (see PUTNAM 2000) and be selective about news information, such as providing public forums for citizens to obtain broader perspectives about candidates or an issue (e.g. FISHKIN 1995).

In a society of monotone news source, the story is different. Selective perception is likely to facilitate the homogenization of preference at the aggregate level. In deed, the homogenization of the public's preference should not be simply attributed to this selective perception mechanism; instead, we see it as a result of the synthesis of the three forces—selective perception of the information 0 that makes half of the audience favoring 0 grow resistant to the influence from their network members favoring 1, the homogenizing effects from self-selected like-minded network members that makes those favoring 0 less likely to change, and the autoregressive influence of the communication networks that make individuals favoring 1 conform to the majority (contrast Experiment 4 against Experiment 5 in Table 1).

Researchers concerning democratization across the world may associate this pattern of Experiment 4 to non-democratic regimes where news sources are controlled by the government or a political party. This pattern can also be associated to a democracy where the news media stand together to broadcast a certain preference. We predict that a pattern of Experiment 4 (see Figure 2) can be transformed to a situation like the pattern of Experiment 2, when alternative news source becomes available, or to the pattern like Experiment 3, when citizens, particularly those favoring 0, turn to ignore the source, or even distrust or reject the biased source of political education. For example, the pattern of Experiment 4 may be similar to the homogeneous communist society in Poland before 1989. Poland is one of new democracies whose democratization was triggered by media liberalization. The emergence of a diverse media free of direct political interference is both a cause and a characteristic of the democratization process (MILLARD 1998). From our perspective, the growing diversity in citizens' preference about whether or not adopting democracy underlies such democratic transition. Latent disagreement about the government can grow dramatically when individuals become less willing to trust the global news source. If all individuals unhook themselves from the influence of the monotone sources, the pattern of preference distribution of that society is likely to evolve in a path like Experiment 4 —> Experiment 5 —> Experiment 3 or Experiment 2.

We acknowledge that ABM is more like a "thought experiment" (AXELROD 1997a) than an approach to predict the future. Simulation results are heuristic than empirically suggestive. This does not say, however, that results derived from ABM should not be bridged to empirical approaches. Instead, this paper welcome inspection of the implications with case studies and empirical examinations about the suggested relationships. For example, the visualized patterns of Experiments 2 and 3 in Figure 2 suggest that individuals residing within a boundary of an opinion cluster in Experiment 3 are more likely to perceive a greater level of homogeneity or agreement than those in Experiment 2. Efforts to validate heuristics drawn from such social simulations will help the construction of external validity of the model.

Future research applying ABM in general, or our model in particular, to the study of political communication needs to address the following three issues. Finally, there is much room to fine-tune our model to study public opinion. In the present project, we assume a low and fixed proportion of elites (i.e. the politically aware agents). Although a study about the influence of varying the number of elites is beyond the scope of this

paper, we look forward seeing more applications of ABM (e.g. BOWDEN and MCDONALD 2006), to the study of the influence of the increase or decrease of such elite agents on the dynamics of opinion formation. Moreover, as the picture provided by Experiment 2 resembles most modern democratic regimes that preserve highest level of preference diversity, we suggest future studies tune the role of news media and communication networks and see how such changes in context affect the characteristics of opinion formation.

Second, technically one should consider add complexity to the model. Agents of the model in this paper are diversified by 6x2 dimensions (six variables—memory capacity and propensity to discuss politics, to access the media, and to perform selective perception—and two classes—the politically aware and the politically unaware). Future studies extending this project may consider adding variance to the following elements or parameter values of the model to answer specified questions: the diversity of the propensity to conform to the majority (e.g. GALAM 2005b), the scope of media influence (e.g. GONZALEZ-AVELLA ET AL. 2006), the size of networks, the strength of news media influence, the number of issues considered, the strength of the news media, the mechanism of selective perception on messages from network members, the difference between political experts and general voters regarding various degrees of selective perception (see also FIORINA ET AL. 2005), and a new class of agents representing "independent voters". Adding complexity to the model may not change the fundamental patterns found with a concise model; doing so increases the internal validity of the original model design. If a newly introduced parameter or an alternative assumption is found to change a pattern found in the literature, however, the new parameter or the new assumption will in tern contribute to model design and theory development (e.g. HUCKFELDT and MENDEZ 2004).

Finally, cross-disciplinary study about information processing, social cognition and political communication are expected to advance the development and application of the present research. Researchers will need to catch up with the development of selective perception theory and empirical findings about voting behavior, such as if (and how) accessing the media is correlated with discussing politics and how individuals conform to or resist against the influence of the majority. Our conclusions are derived directly from our model design, which is based on a number of assumptions that worth examination in cross-disciplinary studies, such as

- Individuals' communication networks are composed of a limited number of self-selected members;
- Individuals tend to seek like-minded political experts as major political discussants;
- Individuals selectively choose their political information sources;
- Individuals have limited and fixed capacity to store information;
- The level of individuals' political knowledge or expertise remain stable over time;
- While discussing politics, individuals differentiate the implicit message held by their discussants, make simplistic judgments about the other's positions, and add that impression to its existing evaluation of an issue (a receive-accept-sample process);

- The politically aware individuals are more efficient and selective than their politically less aware counterparts in the process of seeking and processing political information;
- The politically aware individuals account for a small portion of the public;
- The choice of news media reflects an individual's partisan orientation.

Whenever these assumptions are modified or advanced, we will need to update corresponding the model design and check if previous patterns still hold. This task leaves a great level of uncertainty to ABM modelers, but we think is where physics, communication scholars, social psychologists, computer scientists, and political scientists contribute a better understanding of human complex system.

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