Online Processing, Memory-based Processing, and an Integrated Model of Candidate Evaluation:
A simulation-based empirical investigation

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〈CONTENTS〉

【ABSTRACT】

This article compares online processing, memory-based processing, and an integrated model of the two, using the empirically observed changes in candidate evaluation during the U.S. presidential election of 2000. The study demonstrates that the online and memory-based processing models, which have often been considered as fundamentally different, are in fact complementary to each other and can be accomodated within a coherent, more comprehensive framework. Also, the simulation result of the study suggests that the integrated model fully captures a motivatied reasoning while the online model and memory-based processing model do not, and that this is the key reason why the integrated model outperforms the other two in accounting for the responsiveness and persistence of candidate evaluation observed in the data.

Ⅰ. Introduction

Many scholars have raised the need to incorporate into our explanations of political behavior the scientific knowledge about how people obtain, store, retrieve, and use information to make judgment and choice.[1] Important theoretical progress has been made in political science to address this need, most notably, the online and memory-based information processing models.[2]

However, given recent research developments in psychology and political behavior, these models are limited in important ways. For instance, while the online processing model can account for why individuals can remember how much they like or dislike a political candidate without being able to say why they feel the way they do, it cannot explain why their survey responses are often influenced by such seemingly irrelevant factors as changes in question order and wording ("response effects"). Conversely, while the memory-based processing is capable of explaining the "response effects," it cannot account for the finding that voters' candidate evaluation is systematically related to the campaign information they have been previously exposed to but are unable to recall. I believe that a more comprehensive model of political judgment is necessary to improve our understanding of how ordinary voters form and revise their judgments of political objects (political candidates, parties, groups, and issues).

On the other hand, the online and memory-based processing models have often been narrowly cast as competing and fundamentally different. However, in my view, there is no reason to view them in this way. As I hope to demonstrate in this article, they are

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1) For example, R. R. Lau and D. P. Redlawsk, "An Experimental Study of Information Search, Memory, and Decision Making during a Political Campaign," in J. Kuklinski (ed.), *Political Psychology and Public Opinion* (New York: Cambridge University Press, 2000); E. Ostrom, "The Institutional Analysis and Development Approach," in E. T. Loehman and D. M. Kilgour (eds.), *Designing Institutions for Environmental and Resource Management* (Cheltenham, UK: Edward Elgar Publishing, 1998), pp. 68-90; G. Robert Boynton and Milton Lodge, "Voter's Images of Candidates," in Arthur Miller and Bruce Gronbeck (eds.), *Presidential Campaigns and American Self Images* (Boulder, Colo.: Westview Press, 1994), pp. 159-75; D. C. North, *Institutions, Institutional Change and Economic Performance* (Cambridge: Cambridge University Press, 1990).; Herbert A. Simon, "Human Nature in Politics: The Dialogue of Psychology and Political Science," *American Political Science Review* 29 (1985), pp. 293-304.

2) For the online processing model, see M. Lodge, M. Steenbergen, and S. Brau, "The Responsive Voter: Campaign Information and the Dynamics of Candidate Evaluation," *American Political Science Review* 89-2 (1995), pp. 309-26. For the memory-based information processing model, see John Zaller and Stanley Feldman, "A Simple Theory of the Survey Response," *American Journal of Political Science* 36-3 (1992), pp. 579-616; and Roger Tourangeau, Lance J. Rips, and Kenneth Rasinski, *The Psychology of the Survey Response* (Cambridge: Cambridge University Press, 2000).

complementary rather than competing and can be fully accommodated into a single and coherent theoretical framework. In fact, they can be best viewed as capturing different aspects of the same, underlying psychological process of judgment.

Recently, Kim, Taber, and Lodge demonstrated that a psychological model that incorporates both the online and the memory-based processing implies a motivated reasoning—discounting contradictory information to the prior beliefs while taking consistent information more or less as its face value—and that it is a key factor to account for why candidate evaluations are often persistent while at the same time responsive to campaign information.[3] However, they did not provide any justification regarding why the online and the memory-based processing models can and should be integrated.

In this article, I attempt to show that the online and the memory-based processing models are in fact complementary and can be fully accommodated within a single, coherent framework and that the integrated model does a better job in accounting for the empirical dynamics of candidate evaluation. The online processing, the memory-based processing, and the integrated model can be represented as special cases within the framework proposed by Kim et al.,[4] applied to the empirical changes in candidate evaluation observed during the 2000 U.S. presidential election, and examined for how closely they can track the observed dynamics.

The article is organized as follows. The next section reviews the online and the memory-based processing models. The third presents Kim et al.'s model of political judgment and shows how the online processing, the memory-based processing, and a hybrid of the two can be represented within the model. The fourth section describes the data. The fifth presents and discusses the simulation results. The final sections provide discussion of its major implications and concluding remarks.

II. Online and Memory-based Processing Models

According to the online processing model,[5] people update their attitudes toward

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3) Sung-youn Kim, Charles Taber, and Milton Lodge, "A Computational Model of Citizen as Motivated Reasoner: Modeling the 2000 Presidential Election," *Political Behavior* (forthcoming 2009).

4) Ibid.

5) Reid Hastie and Nancy Pennington, "Notes on the Distinction Between Memory-based and On-line Judgment," in John Bassili (ed.), *On-Line Cognition in Person Perception* (Hillsdale, N.J.: Lawrence Erlbaum, 1989), pp. 1-19; Lodge, Steenbergen, and Brau (1995); Milton Lodge and

political objects online whenever they encounter new information about them. In effect, it assumes that voters maintain a running tally (summary evaluative feeling) for political objects in long-term memory. That is, when an individual encounters new information about an object, she brings the evaluative feeling (e.g., good or bad) about it into conscious working memory, updates it using the new information, and then stores it back to memory. Moreover, after updating her evaluation, the individual may forget the information that influenced her evaluation. This online processing has been demonstrated by a number of experiments. In particular, Lodge, Steenbergen, and Brau showed that the subjects' evaluations of candidates were systematically related to the campaign information they have been previously exposed to, although they were unable to recall it.[6]

The model has made important contribution to our understanding of political judgment. In particular, it provides an answer to the lingering question about ordinary voters' ability to make informed choices. If, as many empirical studies attest, American voters knew so little about political affairs, how could they make informed political choices, which form a necessary basis for the very working of democratic politics? The online model suggests that they can still make informed choices; although they may forget the specific content of information they encounter, their implication is more or less captured by the online tally, which they later use to make political choices.

Conversely, the memory-based processing model postulates that voters typically possess different and often conflicting beliefs about political objects, public policy issues in particular, rather than fixed "true" attitudes.[7] Specifically, when they are asked to evaluate a political object, their evaluation is constructed off the top of their head, reflecting the considerations that happen to come to mind on the spot. Moreover, the retrieval of these considerations is governed by a stochastic sampling process, where those considerations that have been recently made salient are more likely to be sampled.

As Zaller and Feldman demonstrated, the memory-based processing model is consistent with a number of robust findings in survey-based opinion research.[8] As is well known, many empirical researches show that American voters' attitudes toward policy issues are often extremely unstable, to a degree that they are indistinguishable from "none attitude." Moreover, they are often influenced by such insignificant factors as variations in question order, question wording, and personal characteristics of

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Charles S. Taber, "The Primacy of Affect for Political Candidates, Groups, and Issues: An Experimental Test of the Hot Cognition Hypothesis," *Political Psychology* 26-3 (2005), pp. 333-487.

6) Lodge, Steenbergen, and Brau (1995).

7) Zaller and Feldman (1992); Tourangeau, Rips, and Rasinski (2000).

8) Zaller and Feldman (1992).

interviewers. The memory-based processing model provides a coherent account for these findings. In addition, it also gives an answer to a normative question. If voters' political attitudes are extremely unstable and change in response to irrelevant factors, how can we be sure that meaningful public opinion even exists? The memory-based processing model implies that although reported political attitudes may appear unstable and erratic, they still reflect the real public opinion. After all, the considerations that come to mind at the time of judgment, which vary from one situation to another, ultimately depend on voters' existing knowledge structures—the changes in reported attitudes occur only within the boundary of voters' knowledge structures. Consequently, the attitude reports can still be regarded as a valid measure of the real public opinion, especially when multiple opinion poll results are combined.

However, the online and the memory-based processing models are also limited in important ways. Empirically, it is quite apparent that the online model is not capable of accounting for the response effects and the memory-based model cannot explain why voters often remember how much they like or dislike a candidate without being able to explain why. Theoretically, it is fair to say that they capture only a part of the process underlying judgment formation and change. The online model almost exclusively focuses on affective processes, virtually ignoring such important cognitive factors as the role of voters' prior beliefs (e.g., affirmative action discriminates whites) in judgment (e.g., attitude towards affirmative action). In contrast, the memory-based model is mainly concerned with how prior beliefs and considerations influence judgment, ignoring the role of affect.

Given recent developments in cognitive and social psychology, however, these approaches are no longer tenable. One of the most important lessons from contemporary studies in psychology is that human mental processes generally occur as a mixture of cognition and affect; they are inseparable and interplay to produce judgment and behavior. For instance, there is overwhelming evidence that the affective feeling about an attitude object (e.g., positive feeling about Obama) immediately comes to mind upon mere exposure to stimuli (e.g., the string "Barack Obama" in a newspaper headline) before cognitive appraisals (e.g., a recognition that the string "Barack Obama" refers to President Obama). Moreover, once retrieved, it automatically and unconsciously influences the processing of subsequent information.

Ⅲ. An Integrated Model of Political Judgment

Kim, Taber, and Lodge proposed a model of political judgment named *John Q. Public* (JQP)[9] that integrates the online and the memory-based processing based on the classic cognitive paradigm embedded in the ACT-R cognitive architecture (*The Adaptive Character of Thought — Rational*).[10] Specifically, the model incorporates cognitive and affective structures and mechanisms into a coherent framework: 1) knowledge and attitude representation in long-term memory (LTM); 2) accessibility mechanisms for concepts in LTM, which determine how easily and fast there may be retrieval into conscious working memory (WM); 3) processes for attitude construction from accessible information in memory; and 4) processes for the expression and updating of cognitive associations and attitudes. In this section, I discuss each of these mechanisms and show how the model includes the online and the memory-based processing models as its special cases.

1. Knowledge and Attitude Representation in Memory

The foundation for memory processes of the model is the classic cognitive learning paradigm most closely associated with John R. Anderson's architecture of cognition.[11] This theoretical system rests on four basic axioms:

> *Axiom 1, Modularity:* The human cognitive system consists of relatively independent subsystems (modules) such as a central processing system, goal system, and memory system.
> *Axiom 2, Adaptivity and Efficiency:* The human cognitive mechanism is adaptive to the structure of the external environment and has evolved to be an efficient, though not necessarily parsimonious, information-processing mechanism.
> *Axiom 3, Parallel and Serial Processing:* Cognitive processes are a mixture of parallel and serial processing. Parallel processing operates rapidly and efficiently because

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9) Kim et al. (forthcoming 2009).
10) ACT-R cognitive architecture is a leading modeling framework used in cognitive science for a wide range of learning behaviors, among them language comprehension, the recognition and recall of information, inferencing, the formation of beliefs, and the learning of complex skills. However, it lacks affective mechanisms and thus any mechanism for preference updating, which are essential to current theories of political information-processing. John R. Anderson, D. Bothell, M. Byrne, S. Douglass, C. Lebiere, and Y. Qin, "An Integrated Theory of Mind," *Psychological Review* 111-4 (2004), pp. 1036-60.
11) Ibid.

multiple processes operate simultaneously, while serial processing is slower and less efficient because only one process may occur at a time (as is characteristic of conscious deliberation).

 Axiom 4, Semantic Structure of Memory: Human long-term memory is semantically structured in associative networks.

Axioms 1 through 3 are embodied in the design of the ACT-R modeling framework[12] used to build the model and will not be discussed here. Memory structures and processes (Axiom 4), however, require further elaboration because our approach differs from the classic cognitive paradigm built into ACT-R. In particular, JQP (John Q. Public) brings evaluative affect center stage; one's likes and dislikes for "objects" (e.g., leaders, groups, and issues) in memory play a central role in the model:

 Axiom 5, Hot Cognition: Virtually all social concepts in memory are affectively charged. With repeated co-activation sociopolitical concepts become positively or negatively charged and this affective evaluation—positive, negative, or both, strong or weak—is linked directly to its conceptual representation in long-term memory.[13]

By election eve, citizens who have been exposed to the campaign will have formed impressions of the candidates, parties, and issues, and these evaluations will come into play automatically on exposure to new information.[14]

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12) Ibid.
13) Robert Abelson, *Computer Simulation of Personality* (New York: Wiley, 1963); Lodge and Taber (2005).
14) Milton Lodge and Charles S. Taber, "Three Steps Toward a Theory of Motivated Political Reasoning," in Arthur Lupia, Mathew McCubbins, and Samuel Popkin (eds.), *Elements of Reason: Cognition, Choice, and the Bounds of Rationality* (New York: Cambridge University Press, 2000), pp. 183-213; Lodge and Taber (2005).

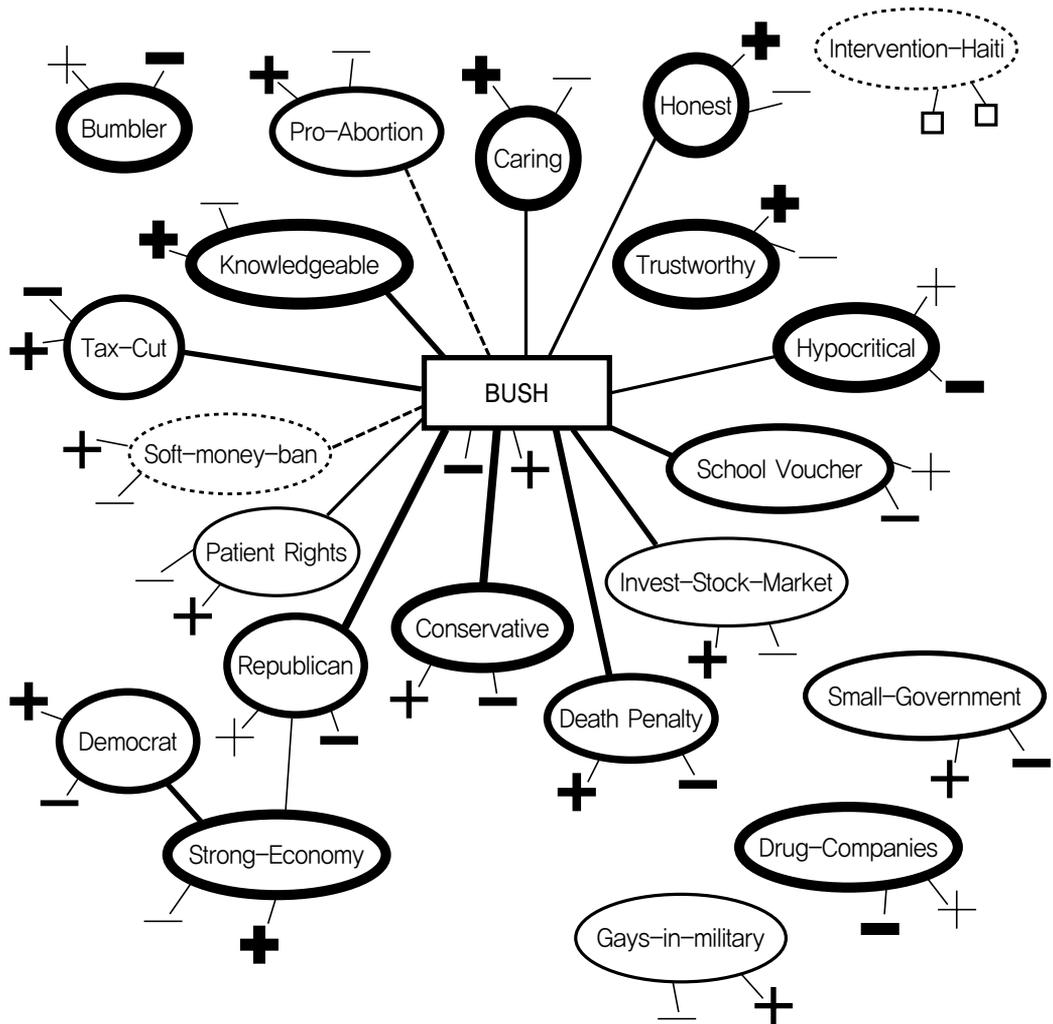Figure 1. Initial Knowledge Structure about Bush for Liberals

Figure 1 illustrates the theoretical framework for memory (Axioms 4 and 5), using part of the knowledge structure about George W. Bush of a typical, liberal voter. Each node or concept in memory is represented by an oval, the border-thickness of which varies to indicate differences in accessibility. For the conflicted liberal shown in Figure 1, the traits "caring", "honest", "bumbler", and "hypocritical" are all quite accessible, while the issues "patients' rights" and "gays in the military" are less accessible. Associations between pairs of nodes are represented by connecting lines of varying thickness, which indicate their strength of association. So "conservative" and "Republican" are more closely associated with Bush in this respondent's belief system than are Bush's

character traits. Plus and minus signs linked to the nodes represent positive and negative attitudes about the memory objects. A summary evaluation of an object may be obtained by combining the positive and negative valences (as when a survey respondent is asked for a thermometer rating of a candidate), but the theory can also represent ambivalence in cases where a node (e.g., "small government") carries both positive and negative affect. Finally, every aspect of the initial knowledge structure—the particular object nodes and associations, the strengths of these nodes and associations, and the valences and strengths of evaluative tags attached to the nodes--change as citizens and agents respond to information throughout the campaign.

2. Accessibility of Memory Objects

Objects in long term memory differ in their accessibilities, depending on the frequency and recency of past retrievals (practice and order effects), activation spread to the node from associated concepts currently being processed (as when thinking about "Bush" activates an associated concept, "Republican"), and the degree of affective congruency between the node and information currently being processed (as when thinking about a positive concept like "sunshine" activates other postive concepts). All of these effects occur spontaneously and automatically, outside of conscious awareness.

These influences on accessibility except affective congruency are part of the classic cognitive paradigm and built into ACT-R. Affective congruency requires two new axioms and the development of additional procedures.

> **Axiom 6, Primacy of Affect:** Affect enters the processing stream before other thoughts and appraisals,[15] thereupon influencing the retrieval and interpretation of subsequent information.[16]
>
> **Axiom 7, Affective Congruency:** Information in memory that is affectively congruent with the information currently being processed is more accessible, while affectively incongruent concepts in memory are less accessible.[17]

Hundreds of experiments in social and cognitive psychology document that affect

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15) Robert Zajonc, "Feeling and Thinking: Preferences Need No Inferences," *American Psychologist* 35 (1984), pp. 151-75.
16) Charles S. Taber and Milton Lodge, "Motivated Skepticism in the Evaluation of Political Beliefs," *American Journal of Political Science* 50-3 (2006), pp. 755-69.
17) Russell Fazio, "On the Automatic Activation of Associated Evaluations: An Overview," *Cognition and Emotion* 15-2 (2001), pp. 115-41; Lodge and Taber (2005).

enters the decision stream before cognitive considerations. Neurological studies show that the "affective system" follows "quick and dirty" pathways that rapidly prepare us for approach-avoidance responses.

The accessibility mechanism of JQP is given by Equation 1.

$$A_i = B_i + \sum_{j=1}^{n} W_i \Big[(S_{ji} - \ln(F_j)) + \gamma C_{ji} \Big] + N(0, \sigma^2) \tag{1}$$

where A_i is the activation level of node i, B_i is the base level activation of node i, W_j is the attention weight for node j (for $j=1$ to n, where n is the number of nodes currently being processed), S_{ji} is the strength of association between nodes j and i, F_j is the number of nodes linked to node j, γ is a parameter governing the weight given to affective congruence, C_{ji} is a trichotomous indicator of affective congruency between nodes j and i, and $N(0, \sigma^2)$ is normally distributed noise with a mean of 0 and standard deviation of σ.

Equation 1 consists of two primary subcomponents: B_i represents the residual effects on the accessibility of node i of past processing and memory decay; the complicated term following the summation sign represents the cumulative effects of other memory nodes on the accessibility of i, divided into spreading activation, $S_{ji} - \ln(F_j)$, and affective congruency, γC_{ji},[18] effects. Note that both spreading activation and affective congruency effects are limited by the amount of focus (W_j) that may be given to node j, which is normally set at $1/n$ to represent the diminishing influence of any given concept when the number of concepts currently being processed increases. A second cognitive limitation built into Equation 1 is the fan effect (F_j), which restricts the amount of activation that can be spread from node j to i when j is linked to a large number of other nodes.

The base line accessibility, B_i, captures the practice and recency effects on accessibility. The more frequently and recently nodes have been activated in the past, the stronger will be their baseline accessibilities.

$$B_i = \ln \left(\sum_{j=1}^{m} T_{ji}^{-d} \right) \tag{2}$$

where B_{it} is the baseline activation of node i at time t, m is the number of times node i has been processed in the past, T_{ij} is the elapsed time since node i was processed the jth

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18) S_{ji} represents the strength of association from node j to node i. It is an increasing function of the number of times node j has sent activation to node i, and it is not symmetrical (John R. Anderson, *Rules of the Mind* [Hillsdale, N.J.: Erlbaum, 1993]). $C_{ji} = 1$ when nodes j and i share the same valence (positive or negative), $C_{ji} = -1$ when they have different valences, and $C_{ji} = 0$ when either of them is neutral.

time, and d is a parameter representing the rate of memory decay that will occur as time passes. So B_{it} increases with the number of times node i has been processed and with the recency of those activations, and it decays over time.

3. Memory-Based Attitude Construction

A basic task of democratic citizenship is the construction of attitudes about issues, parties, and candidates, as these underlie such consequential political behavior as voting and other forms of active participation.[19]

> ***Axiom 8, Attitude Construction:*** Summary evaluations of objects (attitudes) are
> constructed by integrating the evaluations of objects that are accessible at the time of
> attitude construction.[20]

Given the primacy of affect, it is clear that an evaluation of an attitude object will be first influenced by the evaluative tag attached to the object. This axiom posits that the evaluation is likely to be further influenced by any considerations about the object that come momentarily to mind. In JQP, this attitude construction process is implemented as a weighted average of accessible evaluative links.

$$CA_i = (1-\delta)OL_i + \delta\Big[\sum_{j=1}^{n} a_j OL_j\Big], \ a_j = \frac{(A_j/A_i)}{\underset{j}{\Sigma}(A_j/A_i)} \ , \ \text{for } j \neq i \text{ and } Aj \rangle 0 \quad (3)$$

where CA_i is the constructed evaluation of attitude object i, δ is a parameter that controls the influence of other currently accessible considerations (the js) relative to the evaluative tag already stored for object i (OL_i), OL_j is the existing evaluative tag for node j, Ai and A_j are the accessibilities of nodes i and j, a_j is the normalized accessibility of j relative to i, and n is the number of other accessible considerations at the moment of attitude construction.

Observe that the influence of each consideration is weighted by its relative accessibility (a_i) and that only currently active objects ($Aj \rangle 0$) exert influence. Consequently, which

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19) Donald R. Kinder, "Opinion and Action in the Realm of Politics," in Daniel T. Gilbert, Susan
T. Fiske, and Gardner Lindzey (eds.), *The Handbook of Social Psychology*, 4th ed. (Boston:
McGraw-Hill, 1998), pp. 778–867; Charles S. Taber, "Information Processing and Public Opinion,"
in David O. Sears, Leonie Huddy, and Robert Jervis (eds.), *The Handbook of Political Psychology*
(New York: Oxford University Press, 2003), pp. 433–76.
20) Zaller and Feldman (1992); Tourangeau, Rips, and Rasinski (2000).

considerations enter this construction process change dynamically through time. If no considerations are retrieved from memory at the time of attitude construction (i.e., n = 0), because either none is accessible at the moment or the attitude object has no associations in memory, then, $CA_i = OL_i$.

4. Online Processing of Attitudes

There is substantial evidence that attitudes and cognitive associations are routinely updated online, at the time that relevant information is encountered, with the evaluative implications automatically stored back to memory as OL tallies.[21]

> *Axiom 9, Online Processing:* Evaluations linked to objects in memory are updated continually and automatically upon exposure to new information, reflecting the influence of momentarily accessible information in WM.

Equation 4 provides a mechansim for online updating.

$$OL_{ir} = \sum_{j=1}^{m} \rho^k CA_{jk}, \qquad \text{for } j \neq i \quad (4)$$

where OL_{ir} is the evaluative tag for node i that exists after processing the rth piece of information, ρ is a parameter that governs the weight of new relative to old information, and CA_{jk} is the attitude toward object j (as constructed by Equation 3), which is the new piece of information associated with node i at processing stage k. Note that $\rho < 1$ implies the evaluative tag for node i becomes more persistent as more information about the object is processed.

CA_{jk} in Equation 4 implies that JQP would interpret new information based on its prior beliefs rather than in a vacuum. For instance, when JQP encounters a piece of information "Bush is honest," the second term of Equation 4 means that its prior beliefs about Bush (e.g., he is a Republican, he is hypocritical, etc.) would come to mind and influence the evaluative implication of the information. And this "interpreted" (constructed) implication is integrated with the prior attitude.

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21) Hastie and Pennington (1989); Lodge, Steenbergen, and Brau (1995).

5. Online Processing, Memory-Based Processing, and Hybrid Models

The model includes online processing and memory-based processing as special cases. A purely online processing model can be implemented by setting $\delta = 0$ and $\rho > 0$. When $\delta = 0$, the constructed evaluation of an object will be determined solely by the evaluative tag attached to it. With $\rho > 0$, there will be some degree of online updating (when $\rho = 0$, there will be no updating of evaluative tag). Observe that all other parameters become irrelevant and do not matter at all when $\delta = 0$.

A purely memory-based processing model may be implemented by setting $\delta = 1$, $d > 0$, and $\gamma = 0$. With $\delta = 1$, the constructed evaluation of an object is completely determined by the weighted valences of considerations that come to mind at the time of attitude construction. $d > 0$ means that more recently encountered information (or considerations) would exert more influence. Note that spreading activation effect, $S_{ji} - \ln(F_j)$, will still be in effect here, in accordance with Zaller and Feldman.[22] $\gamma = 0$ implies that there will be no affective priming effect, which has nothing to do with memory-based processing. Finally, $0 < \delta < 1$, $\rho > 0$, $d > 0$, and $\gamma > 0$ would yield hybrids of the online and the memory-based processing.
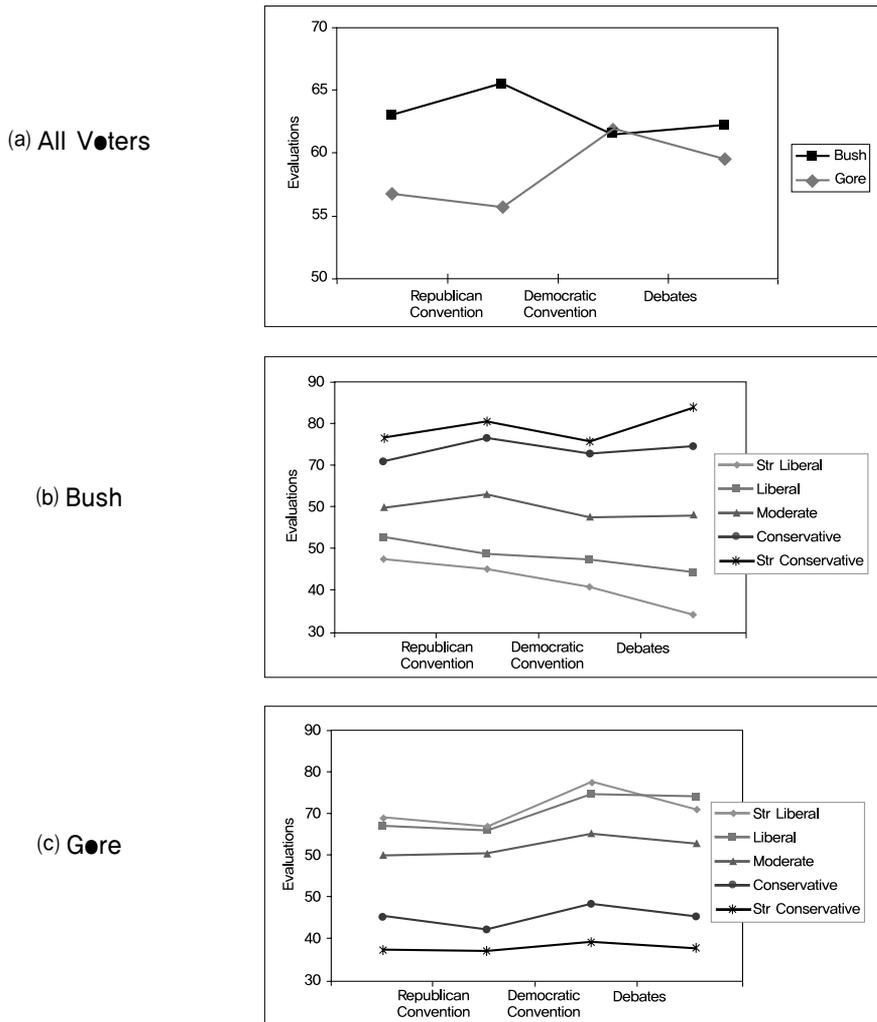
Ⅳ. The Data

The data to be examined in the study is the changes in candidate evaluation during the 2000 U.S. Presidential Election as captured by the NAES (National Annenberg Election Survey) 2000.[23] The NAES 2000 was conducted daily for more than a year, from November 1999 to January 2001, collecting responses from a rolling cross-section of over 100,000 U.S. citizens in total. Figure 2 plots the changes in candidate evaluations of the NAES respondents over the course of three major campaign events during the election. Panel (a) shows the average candidate evaluation (thermometer rating) of Bush and Gore for all voters. Panel (b) and (c) plot those of Bush and Gore respectively for the five self-identified ideological groups—strong conservatives, conservatives, moderates, liberals, and strong liberals.

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22) Zaller and Feldman (1992).
23) Daniel Romer, Kate Kenski, Paul Waldman, Christopher Adasiewicz, and Kathleen Hall Jamieson, *Capturing Campaign Dynamics: The National Annenberg Election Survey* (New York: Oxford University Press, 2003).

Figure 2. Candidate Evaluations over Campaign Events (NAES 2000 Data)

(a) All V●ters

(b) Bush

(c) G●re

The data reveals a set of interesting dynamics of candidate evaluation. First, the candidate evaluation changed in response to the campaign events. As can be seen in panel (a) in the figure, Bush was initially rated slightly more positively than Gore. The gap was then widened by the GOP convention and then decreased over the Democratic convention. After the three debates between candidates in early October, the gap increased again. Panels (b) and (c) plot the candidate evaluations broken down by the five ideological groups, which show similar patterns.

Another important observation is that while candidate evaluation changed responding to the campaign events, the magnitudes of changes were relatively small, that is, they

were quite persistent. For instance, the largest change for all voters was less than 10 points on the 0 – 100 scale. Finally, though not clearly visible in the figure, the evaluation of each ideological group got polarized—the difference in evaluation increased between before the GOP convention and after the debates between candidates. In sum, the data show that candidate evaluations during the 2000 presidential election were both responsive to campaign events while at the same time persistent.

Ⅴ. Methods

1. Why Simulation?

It is in general not easy to test or compare the online, the memory-based processing, and JQP. It is because they are "process models"—that is, they explicitly model the psychological, information-processing mechanisms underlying *the ways people interpret, store, retrieve, and use information to make judgments and choices.* A difficulty is that the observed judgment and behavior is a product of not only the information-processing mechanisms these models postulate but also the respondents' prior knowledge structures and the flow of information they receive. For the present study, changes in candidate evaluation in all three models are influenced by the information-processing mechanisms they postulate, respondents' prior knowledge structures, and the flow of campaign information they encounter. Consequently, in order to compare these models, it is necessary to control for the last two factors. Another difficulty is that the information-processing mechanisms these models put forth are so specific that they include as key factors theoretical constructs that are not directly observable such as evaluative tags, momentarily accessible considerations, accessibility of memory objects, etc.

A feasible way is to apply the models to the data via simulation. The idea is that: first, collect reasonable approximations of the respondents' initial knowledge structures and the flow of campaign information they encountered during the election campaign; second, with these approximations, let all three models have the same initial knowledge structures and process the identical flow of campaign information; and third, examine whether and how well they can track the observed changes. Following Kim et al.,[24] a straightforward simulation design was applied:

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24) Kim et al. (forthcoming 2009).

First, I identify initial knowledge structures for the five self-identified ideological groups among the survey respondents based on their responses to the NAES 2000 pre-election survey. Second, I employ 100 agents to represent a sample of the survey respondents—seven strong conservatives, 29 conservatives, 41 moderates, 19 liberals, and four strong liberals. The initial knowledge structures of the agents are stochastically generated to replicate the actual distribution of ideological beliefs among the survey respondents. Third, I collect a measure of campaign messages from the *New York Times and Newsday*[25] related to three major campaign events during the 2000 election. These events are the Republican and Democratic conventions and the three major candidate debates. The candidate debates are treated as a single event because of their close proximity. Fourth, I conduct the simulation employing the three models. For each model, the 100 agents "read" the distilled newspaper accounts and answer survey questions before and after the three campaign events. This procedure simulates a four-wave panel across the course of the campaign that can be compared to actual NAES survey responses.

2. Initial Knowledge Structures

The primary source for the information to generate initial knowledge structures was the cross-sectional data in the NAES 2000 conducted before the GOP convention. For each of the five self-identified ideological groups, I obtained the distribution (mean and standard deviation) for attitudes toward the candidates, parties, and issues, as well as perceptions of the candidates' traits and issue positions.

For the trait perceptions to be useful, however, we need to assign basic evaluative affect to each trait. That is, when a respondent says "Bush is trustworthy," we need to have some ideas how positive this attribution is. Fortunately, many human traits and other general concepts have been rated by large samples of American respondents, which are reported in Bradley and Lang,[26] and Anderson.[27] These data were used to obtain the distribution of attitudes for traits.

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25) Both the *New York Times and Newsday* were used to get a better measure of campaign messages. Though both are typically considered as liberal newspapers, their coverage of campagin events were somewhat different—Newsday is a local paper while the *New York Times* is a national one. In particular, *Newsday*'s coverage of the debates between Bush and Gore was more one-sided in favor of Gore than the *New York Times*' coverage.

26) Margaret Bradley and Peter Lang, *Affective Norms for English Words (ANEW)* (Gainesville, Fl.: The NIMH Center for the Study of Emotion and Attention, University of Florida, 1999).

27) Norman Anderson, "Likableness Ratings of 555 Personality-trait Words," *Journal of Personality and Social Psychology* 9-3 (1968), pp. 272–79.

The initial knowledge structures of the individual agents were generated in the following way. First, an agent was created and assigned to a basic ideology (according to the frequencies found in the survey data). Second, memory objects were created for every political (e.g., Bush, abortion, tax cut, etc.) and general (e.g., honest, right, trustworthy, etc.) concept asked about in the NAES 2000 survey. Third, initial baseline accessibilities of the political memory objects were set using the response rates for relevant survey items as proxies for frequency and recency of use. Fourth, semantic associations (links in Figure 1) among these memory objects were created when such associations were indicated in the NAES data for the given ideological subgroup. For instance, the strengths of associations among concepts were set according to the subgroup's mean response to such survey items as "How strongly do you agree that Gore is trustworthy" or "How strongly do you agree that Bush supports a tax cut." Fifth, initial evaluative affect was assigned for each memory object according to the survey responses for the given ideological subgroup, Bradley and Lang, and Anderson's data.[28]

In short, initial accessibility baselines, strengths of links, and evaluative affects were all generated stochastically following the distributional properties (mean and standard deviation) of the survey data for the given ideological subgroup. Though all agents likely fall within the "normal" range of beliefs for their ideological subgroup, they do differ idiosyncratically in their specific beliefs (links and accessibilities) and attitudes (evaluative affects), so that each draw of 100 agents forms a unique sample.

3. Campaign Information

Campaign information was obtained from *Newsday and New York Times* reports about the campaign events: the Republican Convention (7/31–8/3), the Democratic Convention (8/14–8/17), and the three debates (10/3, 10/11, 10/17). These news reports roughly represent the information available to citizens in the 2000 election, so that our artificial citizens will be exposed to a similar trajectory of information as were the NAES survey respondents.

The information in these articles was coded into a format accessible to JQP: simple campaign statements attributable to some known actor (e.g., "Bush says Gore is dishonest"). Recognizing that many subtleties will be smoothed away in the process, a procedure to recover the gist meaning of each paragraph of a given news article was

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28) The distributions of attitudes toward general (non-political) concepts are independent of and thus the same for all ideological groups. Bradley and Lang (1999); Anderson (1968).

developed. Each paragraph of each news story was scanned for simple assertions about one of the two major candidates, and that information was extracted as a gist statement. For example, the statement (*Newsday*, third debate, 10/18/2000), "Gore pointed to Bush and said, 'If you want someone who will spend a lot of words describing a whole convoluted process and then end up supporting legislation that is supported by the big drug companies, this is your man,'" was coded "Gore said Bush supports Drug Companies." All qualifications were ignored, all modifiers excised, reducing the complex text to a bare skeleton.

This focus-on-the-gist procedure has several benefits for our purposes. First, it is conservative in the sense that it provides less information to JQP than was potentially available to real citizens (though probably as much as most citizens actually processed). Second, it minimizes the subjective interpretation process, which is the part of content coding most fraught with error. Finally, there is some evidence that citizens process the gist meaning of campaign statements and ignore even not-so-subtle qualifications.[29]

4. Parameter Values

The values of major parameters were optimized to obtain the best result each model can produce—these parameters values were chosen to minimize the mean squared difference (MSD) between the actual and simulated changes in candidate evaluations.[30] In doing so, the parameters that govern classical cognitive processing in the ACT-R environment were kept to their default values (including $d = 0.5$ in Equation 2).[31]

Table 1. Parameter Values Used in Simulation for the 3 Models

Model	Parameter values				
	δ	ρ	γ	d	σ
Online	0	0.93	N/A	N/A	0.4
Memory-based	1	N/A	0	0.5	0.4
Hybrid	0.56	0.94	2	0.5	0.4

The simulation was repeated 100 times due to the random components included in the model. The parameter σ in Equation 1 that governs the magnitude of random component

29) Lodge, Steenbergen, and Brau (1995); Charles S. Taber and Marco Steenbergen, "Computational Experiments in Electoral Behavior," in Milton Lodge and Kathleen McGraw (eds.), *Political Judgement: Structure and Process* (Ann Arbor, Mich.: University of Michigan Press, 1995).
30) The optimization was conducted via grid search.
31) See Anderson et al. (2004).

was just set to 0.4. Also, as discussed earlier; the empirically obtained means and standard deviations were used to stochastically generate the initial knowledge structures. Table 1 lists the parameter values used in the simulation for each model.

Ⅵ. Results and Discussion

Table 2 reports the correlations between the actual and simulated trajectories of the average evaluation of Bush and Gore for all voters for each model. Specifically, it reports the mean and standard deviation of correlations obtained from 100 repetitions. They are 0.89 and 0.03 respectively for JQP, 0.67 and 0.01 for the online model, and 0.56 and 0.03 for the memory-based processing model. The correlations for the five ideological subgroups were qualitatively the same and thus not reported here.

Table 2. Distribution of Correlations between Actual and Simulated Evaluations Across Time over 100 Simulations

Model	Average Correlation Across Time		
	Bush	Gore	Overall
Online	0.52	0.83	0.67 (0.01)
Memory-based	0.44	0.69	0.56 (0.03)
Hybrid	0.91	0.89	0.89 (0.03)

**Note: standard deviations are in parentheses

Clearly, although the online and the memory-based processing models have significant explanatory power, JQP outperforms both. That is, the observed changes in candidate evaluation can be much more closely tracked when both the online and the memory-based processing are allowed than when only one of then is allowed.

Figures 3, 4, and 5 provide a more detailed picture about the performance of the three models. Specifically, they plot the net changes in the actual and simulated candidate evaluations for all voters across the three major campaign events for each model. The results for the ideological subgroups were again qualitatively the same. A couple of observations deserve particular attention. First, the direction of changes in simulated evaluations of all three models correctly matches the actual data in most cases. However, for the online and the memory-based processing models, the changes in simulated evaluation of Gore increased after the three debates while the actual evaluation decreased. Second, the real respondents' evaluation of Bush and Gore and that of JQP got polarized over the three debates, while those of the online and memory-

based processing models became moderated. Finally, for the memory-based processing model, the magnitudes of changes in simulated evaluations are much larger than data or the other models. In sum, JQP reproduces both the observed responsiveness and persistence of candidate evaluation more closely that the online or memory-based processing models. In particular, JQP successfully reproduces the observed polarization in the evaluation of Bush and Gore over the three debates, while the other models do not. And this is the main reason why the correlation of JQP's evaluation with the data got higher than those of the other models.

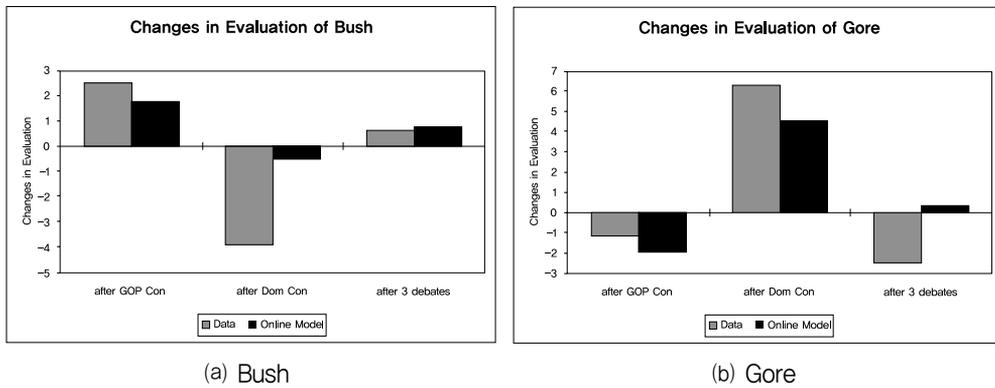Figure 3. The Changes in Candidate Evaluation-Online Model

(a) Bush   (b) Gore

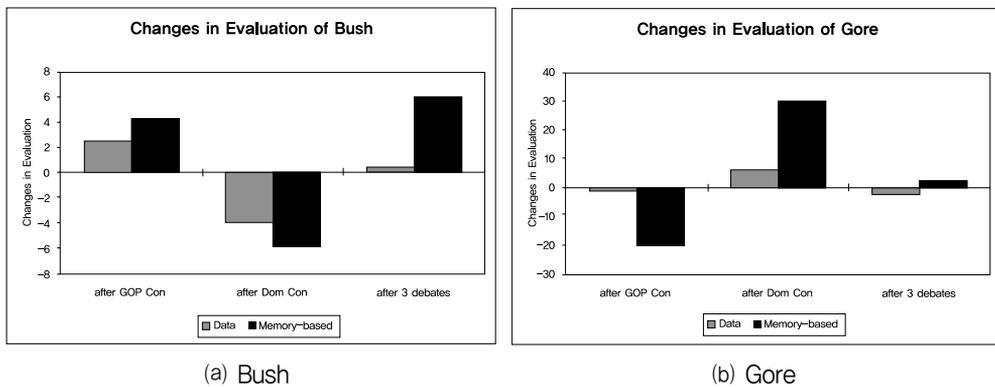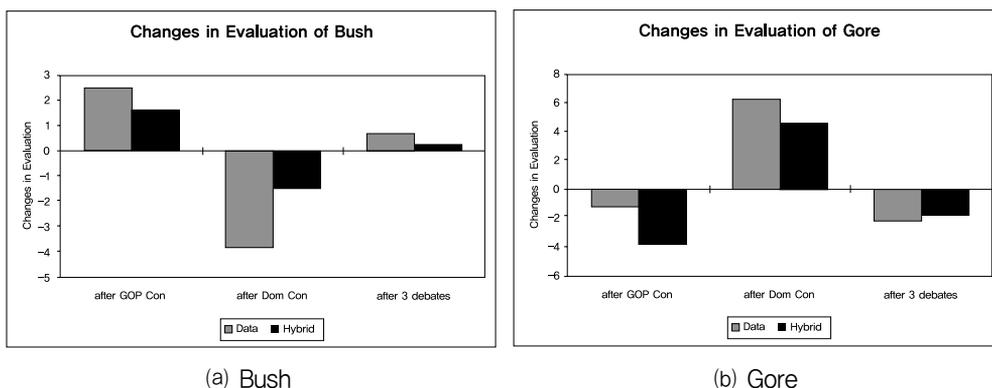Figure 4. The Changes in Candidate Evaluation-Memory-based Model

(a) Bush   (b) Gore

Figure 5. The Changes in Candidate Evaluation-JQP (Hybrid Model)

(a) Bush   (b) Gore

Why does JQP outperform the online or memory-based processing models despite the fact that they had the same initial knowledge structure and processes the identical set of campaign information? More precisely, why could JQP reproduce the observed polarization in candidate evaluation over the three debates while the online or memory-based processing models could not? A plausible explanation is that JQP fully captures a motivated reasoning—discounting contradictory information to the prior beliefs while taking consistent information more or less at its face value—while the online and memory-based processing models do not.

The information processing mechanism of JQP implies a motivated reasoning. Specifically, the prior knowledge structure in JQP is not merely an anchor but actively influences the processing of information and candidate evaluation. For example, consider how the liberal voter depicted in Figure 1 would evaluate Bush when she is asked to. First, her prior evaluative feeling about Bush, which is negative, would make the negative considerations about Bush more accessible (affective priming effect) at the time of judgment, to make the resulting judgment likely to be more negative than otherwise. Second, her prior beliefs (cognitive associations) about Bush would also influence what considerations come to mind. Given the belief structure, such negative considerations as "Bush is a Republican" and "Bush is conservative" are more likely to be retrieved to influence the evaluation. Both of these processes will obviously bias the resulting judgment toward the prior beliefs. Similar arguments can also be made when JQP interprets campaign information and update the evaluative feeling using the information.

Compared to JQP, the online and memory-based processing models do not adequately capture the motivated reasoning. In the online processing model, the prior evaluative feeling about a candidate is merely an anchor and does not play any role beyond that.

Also, the other aspects of prior knowledge structures such as cognitive associations are simply irrelevant in this model. In the memory-based processing model, the evaluative feelings about objects do not even exist and thus do not play any role. Also, affective priming effect is simply irrelevant in this model. In sum, JQP fully captures the motivated reasoning while the other models do not. And this is the key reason why JQP outperformed the online and the memory-based processing models in accounting for the observed responsiveness and persistence of candidate evaluation during the 2000 election.

Ⅶ. Conclusion

Given the recent research development in psychology and political behavior, the online and memory-based processing models, which are arguably the two most important theoretical positions on political judgment, are limited in important ways. Moreover, they have been often narrowly cast and improperly framed as competing and fundamentally different, when in fact they can be best viewed as complimentary to each other.

This study demonstrates that the online and the memory-based processing models can be fully integrated into a single, coherent framework and that this integrated model does a better job in accounting for the empirical dynamics of candidate evaluation than either the online or the memory-based processing model.

Specifically, the online processing, the memory-based processing, and an integrated model of the two were applied via simulations to the empirical observed changes in candidate evaluation over the course of campaign during the U.S. presidential election of 2000. The result shows that the integrated model outperforms the online and memory-based processing models in tracking the observed changes in candidate evaluation. In particular, the integrated model successfully accounts for all major observed dynamics—namely the responsiveness, persistence, and polarization—of candidate evaluation, but the online and memory-based processing models have relative difficulty explaining the persistence and polarization. A closer examination suggests that the integrated model fully captures a motivated reasoning while the other two models do not, which is the key reason for the difference in their performance.

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