Understanding Individual Decision Making using Process Tracing

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Paper presented at the General Conference of the European Consortium for Political Research, September 10-12, 2009, Potsdam, Germany

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I. Introduction and Overview

The view of humans as "boundedly rational," associated with the research of Herbert Simon (1957) and other cognitive psychologists, has spread to many of the sister behavioral sciences, including economics, political science, and sociology. At a certain level, most behavioral disciplines have come to accept the basic starting point of this approach, that humans are "cognitively limited information processors" who have developed numerous cognitive shortcuts and heuristics to negotiate their worlds (e.g., Kuklinski, 2001; Lau, 2003; Lau and Sears, 1986; Lau and Redlawsk, 2006; Lodge and McGraw, 1995; Lupia, McCubbins, and Popkin, 2000; Popkin,1991; Sniderman, Brody, and Tetlock, 1991). At the same time, however, it would be fair to say that few researchers outside of psychology have thoroughly embraced the approach, to the extent of critically examining many of its underlying assumptions, or of thinking through many of the implications of accepting this perspective for political science.

One of the difficulties of fully embracing an information processing perspective is that the underlying cognitive theories operate at such a micro level that it is often hard for researchers from political science, trained to think in more macro terms, to fully appreciate how and why information processing can influence the type of behavior they are accustomed to observing. But an even more daunting impediment is the dearth of serious research methodologies that are well-suited to gathering detailed information processing data in the types of complex social environments that political scientists like to study.

With prior support from the National Science Foundation[2], we have developed one such methodology, which we call *dynamic process tracing* that is uniquely suited for studying decision making in complex social situations. We have applied this technique to a series of studies of election campaigns,

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[1] Earlier versions of this paper were presented at the 2008 Annual Meetings of the Midwest Political Science Association and the American Political Science Association.

[2] NSF grants SES-9411162, NSF grant SES-9321236 helped support the original dynamic process tracing system, while NSF grants SES-0647657 and SES-0647738 have supported development of the updated software described in this paper.

and have developed new insights into the nature of the vote decision as a result (Lau and Redlawsk, 1997, 2001a, 2001b, 2006, 2008; Lau, Anderson, and Redlawsk, 2008; Redlawsk, 2001, 2002, 2004, 2006; Redlawsk and Lau, 2006; Redlawsk, Civettini, and Lau, 2007; Civettini and Redlawsk, forthcoming). But we have only scratched the surface of what can be learned about voter decision making, and the applicability of our technique is much broader than political campaigns. Indeed, it could be used to examine judgment and decision making in almost any complex social situation.

Our goal in this paper is not to examine any new studies as such but instead to describe the purpose of the dynamic process tracing environment (DPTE) and to preview some substantial changes we have under way that will allow any researcher interested in examining decision making over time to make use of this methodology. We argue that given the inherently dynamic nature of a political campaign – it unfolds over time with information coming and going during its course – a fuller understanding of how voters obtain, process, and evaluate the information they encounter requires an approach that allows us to study those voters voter time. Process tracing laboratory studies are one way to do this. And while our methodology can be applied to virtually any context in which a decision is made over time, our focus to date has been on voter decision making in a political campaign environment.

II. Some History of Voter Decision Making Research

We do not think we need to rehearse the history of voting research back to the "beginning" here. But we do want to make some specific points about the nature of most attempts to understand how voters make decisions that lead us to argue that candidate evaluation and choice are processes that are best studied from that perspective. For the most part, typical voting models are *static* models, that is, they operate essentially by identifying independent variables to measure (such as social, economic, and psychological variables) and using variations on linear modeling techniques to identify the coefficients for each of these variables that "best" predict candidate evaluation or the vote choice. Much of the research in this area historically was driven by easy access to survey data. Yet, some exceptions exist, even in the early days of this work. For example, Downs (1957) outlined the decision-making *process*

used by the individual rational voter. But generally mainstream research operated within a paradigm primarily interested in predicting aggregate election outcomes. This lack of focus on process did not seem to very important when party identification appeared to be the single most important factor in the vote choice, and partisanship itself was assumed to be a stable psychological attachment formed early in one's political socialization. The process of voting seemed quite obvious and simple: one would filter information from the media about the candidates through one's political predispositions, while perhaps modifying views based on discussions within various social groups. Self-interest might be factored in, with some evaluation of which party's policies would make one better off. Ultimately, though, one would probably cast a party-line vote.

Computer Simulations of the Vote Decision

Some scholars responded to the inherently static nature of voting models quite early. The Simulmatics Project (Pool and Abelson; 1960) was the first to use computer simulation to test propositions arising out of the sociological models (Berelson, Lazarsfeld, and McPhee, 1954). The simulations made use of more than 130,000 survey responses and classified respondents into 480 voter types, according to demographic and social characteristics. For each type, 52 groups of issue attitudes were tabulated. The data were then used to simulate the outcome of the 1960 presidential election. Ultimately, the computer program made predictions about the vote swing of Republican, Democrats, and independents, and determined that the outcome of the 1960 election was primarily related to religion and partisanship; with issue attitudes adding little to the simulation.

Contemporaneously with the Simulmatics Project, McPhee (1961) developed a computer simulation to examine the social-psychological model of the vote (Campbell, Converse, Miller & Stokes, 1960). This project modeled interactions between individual voters within the groups might influence their decisions. This simulation allowed the researchers to modify parameters of the campaign such as the strength of the farm issue as presented by Humphrey in the Wisconsin primary, resulting in estimates of how the outcome of the election might have changed.

While both studies claimed to be examining voting processes, neither moved past simply identifying weights attached to various social factors and examining changes as the election environment was modified; nor did they really consider actions by individual voters. Both were base don survey research. Shaffer (1972) came closer to studying voting as a process by ignoring the issue of group dynamics and focusing on simulating individual behavior. After explicating the various standard voting models – sociological, social-psychological, and psychological– Shaffer developed computer simulations of the two models then most in vogue; Downs's rational actor model and the Michigan six-component model. His intent was to simulate the process by which voters reached their decisions and to determine which of the two models best represented this process. His findings led him to accept the Downsian notion of utility as central to decision-making while rejecting Downs' cost of information parameter as irrelevant given the ease with which voters could acquire campaign information. Shaffer also incorporated a number of Michigan factors in his model, finding it necessary to add partisan attachment to the formulation of the Downsian model in order make the model reasonably predictive. Finally, he argued that interactions within a voter's primary groups were important in helping a voter either reinforce his or her own dispositions or to eliminate uncertainty and minimize ambivalence. Shaffer's work is noteworthy here primarily because he chose not to use static modeling techniques to simply determine the relative weights of various antecedents to voting. Instead he focused on examining the process voters actually employ in using campaign information to make a decision. Yet ultimately he also was limited by the need to rely on the 1964 American National Election Study, which was clearly better suited towards modeling the vote decision than it was the vote process.

Shaffer's idea of investigating the *process* of individual voting decision-making, rather than the static determinants of the vote seems to have been received with a complete lack of interest. Perhaps it was his (then) esoteric use of computers on which he ran his model simulations. Or, perhaps it was the lack of anything other than survey research from which to build process-oriented models. In any case, political scientists did not appear to be very interested in moving beyond the paradigm set down by the *American Voter* tradition. Meanwhile, in the real world of presidential elections outside of computer

simulations, changes were rapidly occurring. Partisanship appeared to decline and the process of electing a president began to be seen more as a process of "selling" a president.[3] Scholars began to make more effort to understand not only the questions of why voters make the choices they do, but also the question of how voters come to their decisions.

One result was an increasing move away from partisanship as *the* explanatory vehicle, and an increasing focus on the importance of issues and candidate specific factors.[4] Even so, researchers still focused on predicting the aggregate vote and trying to determine the relative importance of the various factors that correlated with voting choices. Debates raged over whether the electorate had changed, whether the *American Voter* paradigm was time-bound, and whether issues mattered at all.[5]

Modeling Voting as a Process

While voting behavior scholars debated the rise and fall of issues, party, and candidate factors in the vote decision, another perspective was developing, directly informed by psychological approaches to human behavior. This perspective saw voters as interacting with their political environment, rather than as vessels into which the environment flowed. It recognized that elections occur over time, that voters are exposed to information about candidates which they seek to put into a perspective, but which changes as the campaign continues. Some consideration began to be given to how voters could process the information they received, how the contents and organization of political memory might affect the

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[3] The idea that marketing presidential campaigns is a lot like marketing consumer products was advanced in some detail in McGinniss (1969.)

[4] See, in particular, the July 1975 special issue of American Politics Quarterly (3:3) which included a number of articles discussing the apparent sea-change in voting behavior witnessed in the late 1960's and early 1970's. (Reprinted in Kirkpatrick, 1976.)

[5] Beginning in the late 1960's, a large amount of space in professional journals was devoted to the question of whether voters had become more issue-oriented in the elections of 1964 and 1968, when compared to earlier elections. The question was whether these elections evidenced a public better able to carry out its civil obligations, through greater knowledge of the issues. While this controversy continued for several years, it seems clear that those arguing that the 1960's elections did not represent some great shift towards issue-oriented voters prevailed, and the political science view of voters did not change very much. For some of the considerations on both sides of the issue, see Pomper, (1972); Nie and Anderson, (1974); Achen, (1975); Nie, Verba, and Petrocik, (1976), especially Chapter 10; and Smith, (1989) among many others. A rather detailed list of earlier studies on issue voting appears in the first footnote of Kessel (1972).

decision process, and the ways in which voters might keep track of the mass of information prevalent during a typical presidential campaign.

Kelley and Mirer (1974) proposed a very simple process oriented model of voter decision making. While they did not attempt to specify how voters received information, or the means by which political information might be filtered and stored in memory, their contribution was to develop a model by which voters might retrieve and use information to make a vote decision. In particular, their process model – the voter decision rule – could be detailed in just one paragraph:

> The voter canvasses his likes and dislikes of the leading candidates and major parties involved in an election. Weighing each like and dislike equally, he votes for the candidate towards whom he has the greatest net number of favorable attitudes, if there is such a candidate. If no candidate has such an advantage, the voter votes consistently with his party affiliation, if he has one. If his attitudes do not incline him toward one candidate more than toward another, and if he does not identify with one of the major parties, the voter reaches a null decision. (1974, p. 574.)

Kelly and Mirer argued that static models could only describe the vote result after actual voting had taken place and could not be used to predict the vote because multiple regression techniques require knowledge of the actual value of the dependent variable and because the weights assigned by regression techniques to the various indicators of the vote change from election to election (p. 573.) Nor did they believe that an ability to predict the outcome of an election after it happened was tantamount to explaining why a voter made the choice that he or she did. But while their rule was a statement of how voters might use campaign information, it did not say anything about the mechanism by which voters would make the comparisons it called for when recalling their likes and dislikes. Nor did they specify how the likes and dislikes came into being in the first place. Even so this work proved a significant early attempt to model voting as a decision-making process.

Meanwhile, Markus and Converse (1979) developed a much more complex simultaneous equation model to describe how voters determine candidate preferences. They explicitly attempted to

formulate “a model [ ] verisimilar to the dynamic cognitive process underlying citizen’s electoral decision making” rather than attempting either predictive accuracy or the determination of the relative importance of various predictors (p. 1055.) Using the 1972-1976 American National Election Study panel, they specified a set of equations which took into account interrelationships between party identification, candidate evaluation, perceptions of candidate personality, and issue positions. By using simultaneous equation modeling they found that partisanship was very stable across elections, but that those voters who voted over time against their professed party identification would be more likely to change party in the future. Perhaps not surprisingly, their results provided confirmation of the basic importance of partisanship in the Michigan model as a perceptual screen influencing the way in which voters viewed candidates and issues.

Markus and Converse also confirmed the importance of candidates in American presidential elections. Across their various equations, candidate evaluations became a major factor in vote choice. They noted that “policy considerations and even partisan orientations affect[] the vote either exclusively or largely through the way they help to shape feelings toward the presidential rivals” (p. 1067.) Thus, it is ultimately the *choice* between two candidate evaluations that determines the direction of the vote most immediately, with partisanship playing a direct role that diminishes as the gap between evaluations of the two candidates widens.

Like Kelly and Mirer (1974), this study took the presence of information as a given, not addressing the question of how voters process the information that comes over the course of a campaign. While they called their method “dynamic”, this referred more to the way in which their various equations influenced each other, rather than the way a campaign itself ebbs and flows. While they proposed a model of cognitive processing related to voting, in truth what Markus and Conversed actually modeled appears to be closely tied to the relative importance of various parameters at the time a decision has to be made. Still, the idea of trying to model a process rather than simply establishing the relative importance of various parameters of the vote provides a precursor to more modern work focused explicitly on information processing.

Using Information Boards to Understand Process

This early research into the candidate evaluation processes was somewhat hampered by its continuing reliance on survey research data. So we now turn away from political science for a laboratory approach that allows us to collect process-oriented data as a decision is being made. Modeling decision making has long been an important part of consumer behavior research. Researchers trying to understand how consumers choose grocery products, for example, found it convenient to array products on an "information board" with the placement of the products generally across the top of the board and a listing of attributes down one side. Within the resulting product-by-attribute matrix would be index cards containing bits of information pertaining to the intersection of each product and attribute. Jacoby and colleagues (Jacoby, Kohn, & Speller, 1974; Jacoby, Speller, & Berning, 1974) used this approach in two studies to determine the effects of increasing information availability on the ability of consumers to choose from among detergents, rice, or prepared dinners. Payne (1980) had college students choose from between 2 to 12 hypothetical apartments represented on an information board. While making their choice, subjects were told to "think aloud" as they decided. This verbal protocol was recorded and used to supplement the decision process information gained directly from observation of the use of the information board. One of the enduring findings of this work was the notion of "information overload" that consumers might encounter so much information about products that they could not effectively process it all, leading to lower quality decisions.[6]

While political campaigns do not proceed in the same kind of organized easy to use arrangement as a grocery shelf, Herstein (1981) showed that the process of information gathering during the campaign could be simulated on an information board. Two hypothetical candidates were created with 45 attributes established for each candidate. Attributes included candidate positions on issues, personal information, and party identification. Subjects stood in front of the information board and chose from index cards for each candidate. The cards were labeled on the visible side with a tag indicating which attribute the card

[6] See Einhorn and Hogarth, 1981; Jacoby et al, 1987; Payne, Bettman, and Johnson, 1993, for reviews of a range of information board studies.

contained. On the reverse was the actual information. Subjects were instructed to examine as much or as little information as they desired and allowed to spend as much time as they wished before making their decision. In addition, subjects were instructed to talk aloud as they made their decision to express what they were thinking verbally. The comments they made were recorded as part of the procedure (p. 848.)

Herstein's goal was to develop a truly process-oriented model of the vote which would define not only what information was considered in order to make a vote decision, but the order in which it was considered and the ongoing evaluations made by voters during the process of information acquisition. In his model voters actively access information, evaluate it, and make candidate comparisons on various attributes, much as they would do so for any consumer product. Herstein found that subjects sought more information when the campaign consisted of two middle-of-the-road candidates quite similar in their positions compared to a race between two clearly distinct ideologues. But in an interesting anomaly, he also found that party identification did not matter much to his subjects, who chose the party attribute far less often than might be expected, and typically chose it much later in the decision process than would be anticipated given the supposed importance of party in American presidential elections.

Herstein's findings exhibit a number of features which may well be artifacts of the static nature of the information board itself and the easy accessibility of all information. Presidential elections do not proceed in an ordered fashion, with all information always available for examination. In addition, voters do not have as much time as they might want to learn about the candidates. In particular, the finding that the partisanship did not matter much is as likely attributable to the artificial nature of the information board as it is a useful finding. In a real general election party can matter because it is an heuristic summarizing a large amount of information that few voters have the time or inclination to learn (Fiorina, 1981; Lau and Redlawsk, 2001, 2006.) In Herstein's static information board there were no constraints on the ability of subjects to learn as much as they wished about the candidates, and thus no need to use a party identification heuristic. Further, the unimportance of party identification also appears because of a choice made in analyzing the data. Herstein made the inaccurate assumption that a subject would choose party identification for both candidates, in the same way that one would look at an issue stand for both to

get all necessary information. However, unlike issue positions, once a subject chose party for one candidate, the party of the other was automatically known, creating no need to choose the party card for the other candidate. Because of the way he counted accesses of information, party then appeared to be much less important, since it was not accessed across both candidates on a regular basis. Still, the idea of the information board as an effective laboratory tool with which voter decision making can be studied has developed substantially since Herstein's study.

III. Studying Candidate Evaluation and Choice

Following Herstein's groundbreaking laboratory study, others have used information boards to examine decision-making and information search in political environments (Riggle and Johnson, 1996; Huang, 2000; Huang and Price, 2001). The technique has also been used to examine foreign policy decision making (Mintz, Geva, Redd and Carnes, 1997; Redd, 2002). And recently Taber and Lodge (2006) have used the information board approach to look at how citizens choose to learn about issues. However, outside of Herstein (1981) there has been little use of this methodology in studying candidate evaluation and the vote choice, though it would seem that process tracing could yield great insights into these processes.

There are, however, some definite drawbacks in using the traditional information board to track political decision making which is what led us to examine an alternative approach we call "dynamic process tracing". In its original design, the information board is *static* allowing constant access to all attributes for all alternatives under consideration. In the context of an election, this would be as if a voter had the ability to access any piece of information about a candidate, be it a position on a particular issue or a personal characteristic, at any time, allowing easy comparison between candidates on any attribute. In a real election, however, information is much less organized, somewhat more chaotic, and the time allowed for learning and information gathering is limited by Election Day. During a campaign, information comes and goes, and candidates do not always make it easy for voters to make an objective comparison or even get a clear understanding of where they stand on issues. Clearly the classic

information board does a poor job of modeling these prominent features of modern political campaigns, or of any decision or judgment task that must be completed in a similar dynamic environment for several reasons:

- With a traditional information board the decision maker can access any information any time she wants, while many social environments have a dynamic quality about them such that information easily available today might be harder to find tomorrow and almost completely gone by the following day.
- All information on a standard information board is equally easy to access, while in many decision environments certain types of information (e.g., hoopla and horse race in a political campaign, product names in most markets) are much easier to find than others (e.g., detailed issue stands, product reliability or customer satisfaction).
- Decision makers must actively choose to learn everything they find out about the alternatives with a standard information board, but much information in many social environments (e.g., television advertisements) comes without any active effort by the decision maker to learn that information.
- Most importantly, decision making with an information board is far too "manageable," too controllable, too easy; while during a typical presidential elections, or end-of-the-year sales events, or particularly busy times at work or other ongoing social situations, decision makers are overwhelmed by far more information than they can possibly process.

In many ways the classic information board represents an “ideal world” for decision making that can be contrasted to voting in an actual political campaign.

Dynamic Process Tracing: A *Better* Methodology for Studying Voter Decision Making.

While it can be useful to study an ideal world, a certain amount of external validity is to be prized in laboratory experiments. To that end we have revised the traditional static information board, modifying it in way which better mimics the flow of information in any dynamic social environment such as a

presidential campaign. Where the static board allows subjects to have access to all available information at all times, our revised dynamic board emulates the ebb and flow of a political campaign by making only a relatively small and ever changing subset of the total information set available at any point in time. The essential feature of the static information board – the ability to trace the decision-making process as it happens – is retained while information about candidates comes and goes. Where standard information boards are easily managed by the subject, our election simulation can overwhelm subjects with information if desired. Where standard information boards allow all information to be available whenever a subject wants it, information during a real election campaign contains a "here today, gone tomorrow" quality, as does our simulation. And, where the standard information board would make all types of information equally accessible, from positions on arcane issues to party identification and poll results, our simulation models the relative difficulty of finding certain kinds of information at different times during a campaign.

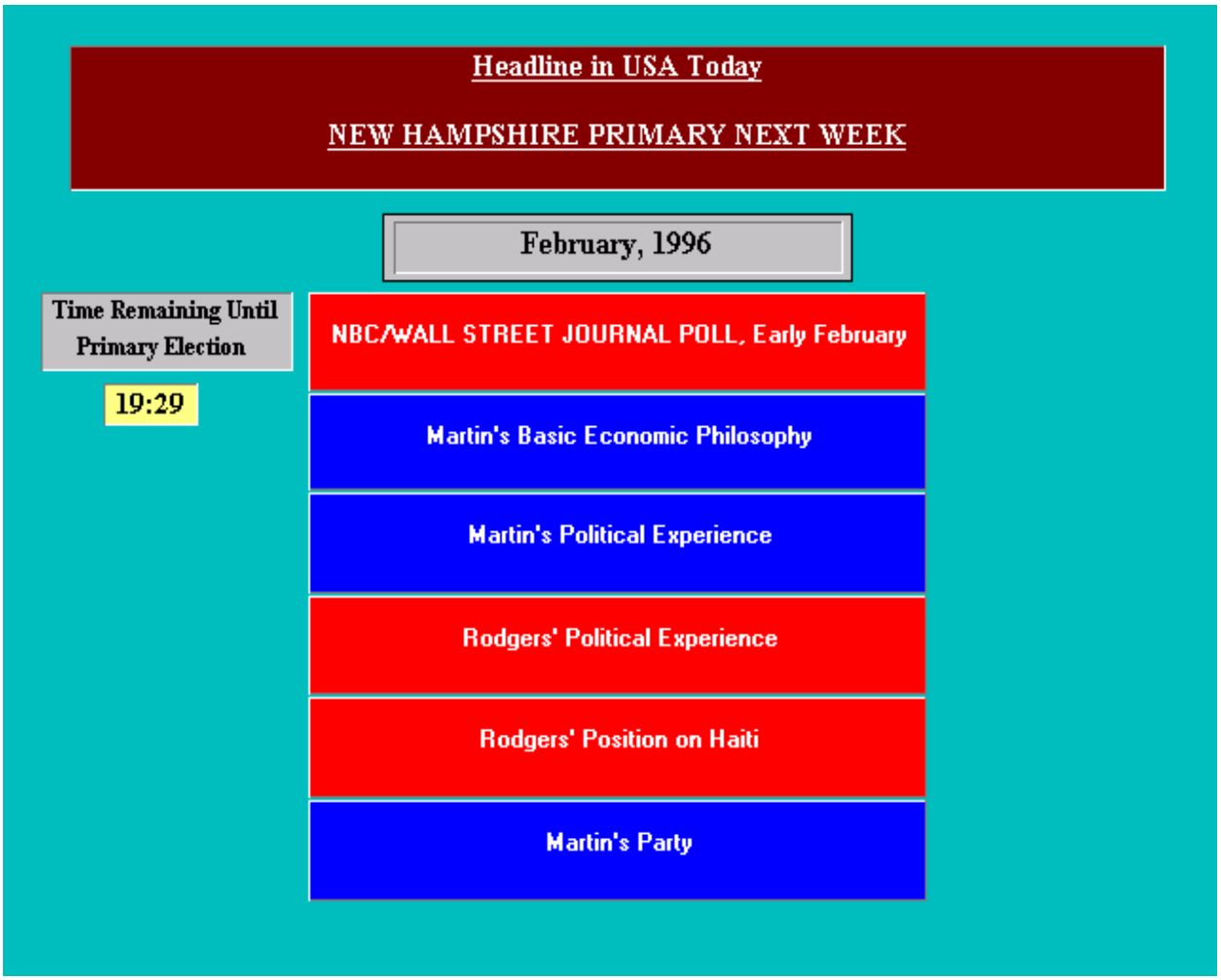
We accomplished this by designing a radically revised information board in which the information – the attribute labels – "scrolls" down a computer screen, rather than remaining fixed in place. (Figure 1 provides an example of the main screen.) Thus there are only a limited number of attribute labels visible on the computer screen at any one time. Most labels include a candidate's name and the particular information that would be revealed if this label were accessed. The rate of scrolling is such that people can read two or three labels before the position changes. Subjects access the information behind the label by using a mouse to click on the label. The scrolling continues in the background while the detailed information is read, however, creating a "cost" in terms of missed information and mimicking the dynamic nature of election information flow. This scrolling format allows only a small subset of a very large database of information to be available at any one time, and it makes the task of processing campaign information much less manageable for the subject. In addition, the relative likelihood of any particular piece of information becoming available is controlled, so that some information (e.g., party identification) is much easier to obtain (i.e., appears much more often) than other types of information (such as detailed policy positions). Finally, at periodic intervals the computer screen is taken over by a

political advertisement for one of the candidates, providing all voters with a fair amount of "free" information they did not actively choose to learn. All of these features make our dynamic information board a much better experimental analog to a political campaign – or to any dynamic social situation.

Our experiments using the dynamic information board have at their base a mock presidential election campaign with eight potential candidates, four Democrats and four Republicans. Most of our experiments have involved both primary and general election campaigns, where 2 or 4 Democrats and 4 or 2 Republicans are competing for their party's nomination in the primary, and eventually one of the Democrats faces one of the Republicans in the general election. All of the candidates are fictitious, although they are realistic in terms of prior political experience, ideological appropriateness for their party, and so on. This allows the benefits of political experience or expertise to be manifest, while still giving us complete control over what information about the candidates is available to voters, and what subset of that total pool of information they choose to consider in making their decision. Subjects "register" as a Democrat or a Republican before the campaign begins, can learn anything they want about any of the candidates during a primary campaign which typically lasts 20-25 minutes (which is only long enough to see a small subset of the total pool of available information), but must choose only among the candidates running in their party. During the general election one Democrat opposes one of the Republicans, and of course voters may support either of those two candidates. We are able to randomly manipulate many different theoretically interesting features of the campaign, including the difficulty of the choice (e.g., the number and/or ideological distinctiveness of the candidates in an election), the equity of the campaign resources available to the different candidates (that is, the number of campaign ads they can "afford"), the nature and amount of specific information about each candidate (e.g., the gender and race of the candidates, the particulars of their policy stands, the credibility of the "sources" of the available information, etc). This gives us a great deal of control over the general nature of the campaign environment, and the ability to randomly manipulate many features of it, while simultaneously giving voters a great deal of discretion over choosing how much and what kind of specific information they want to learn about the different candidates. And in the end we have a very detailed record of those decision

strategies, as we know what information subjects accessed about the candidates, how long they looked at it, how deeply they processed it (which can be inferred from an unexpected memory task), and so on.

Figure 1: A Dynamic Information Board



IV. New Insights into Voter Decision Making.

Most studies of the vote decision are primarily concerned with explaining why the winning candidate or party received the most votes. While we can certainly address that question with our studies, it is much less interesting in the context of the laboratory experiments that provide the stimuli for our experiments. As an alternative, we developed and validated measures of *correct* voting – whether, at the

time our voters had to make their decision, they voted in accord with their "fully informed preferences" (Dahl, 1989) – that is, with what they *would have* decided had they had full information about all of the alternatives in the choice set (Lau and Redlawsk, 1997; Lau and Redlawsk, 2006; Lau, Anderson, and Redlawsk, 2008). We have used our technique to study the relative efficacy of different *decision strategies* – sets of mental and physical operations that an individual uses to reach a decision, including identifying alternatives, searching for information about the possible outcomes associated with the different alternatives, and selecting a method for choosing among the alternatives (Lau and Redlawsk, 2006). We have distinguished between four broad categories of decision strategies, differing in depth (that is, how much of the available information is accessed before the decision is made) and comparability (how evenly accessed information is distributed across alternatives) of search, and tried to place prior models of the vote choice into one of those four categories. Probably our most important finding is that voters' decision strategies influence the *quality* of the choices they make – a finding with implications extending well beyond political campaigns. Our research suggests that voters often make *better* decisions with *less* information. This finding runs counter to the assumptions of neoclassic economic decision theory which has had widespread influence in the social sciences and which guides much current policy making.

Cognitive shortcuts, "heuristics," and other aspects of "low information rationality" (Popkin, 1991) are the common explanation for how people can make "pretty good" decisions without a lot of cognitive effort, and without gathering an inordinate amount of information. The growing conventional wisdom is that cognitive shortcuts allow even uninformed voters to act "as if" they were reasonably fully informed. Our work, however, *directly observes* heuristic use and demonstrates that, counter to the conventional wisdom only political experts are generally aided in their decision making by heuristics. Among relative novices, heuristic use actually *decreases* the probability of a correct vote (Lau and

Redlawsk, 2001, 2006).[7]

Our approach is explicit in recognizing that a vote *decision*, made in the context of an election campaign in which all voters know they must ultimately make a choice, is in certain important ways very different from the process of *making a judgment* or *forming an evaluation* (such as of an incumbent president's job performance), even though it is common to treat the two as essentially identical. That is, most political science models of the vote see the *choice* as nothing more than voting for the most highly evaluated candidate (compare Fiorina, 1981; Kelley and Mirer, 1974; Lodge, Steenbergen, and Brau, 1995; Markus and Converse, 1979). For example, Lodge's *online model* holds that as people encounter new information about a political candidate, they update a "running tally" evaluation of that candidate, but then forget the particulars upon which that evaluation was based, storing in memory only the new updated tally (Lodge, McGraw, and Stroh, 1989; Lodge et al, 1995). The vote choice, according to Lodge, is nothing more than selecting the candidate with the highest online evaluation.

We disagree. We see voters, like all decision makers, as motivated by two primary goals: the desire to make a *good* decision, and the desire to make an *easy* decision. Storing in memory nothing more about the candidates in an election than summary evaluations is certainly an *easy* way to make a decision, but it is not a particularly *good* way of making a decision, especially if those evaluations are formed on the basis of two totally independent sets of criteria. A good decision, as most people intuitively realize, should be based on *comparing* alternatives on a *common* set of criteria, and to do that – except in fairly artificial or contrived situations -- requires memory of the particulars upon which an evaluation is based. We have very strong and clear evidence from our studies that memory matters to the quality of the decisions that are reached (Redlawsk, 2001; Lau and Redlawsk, 2006).

Recently we have modified the environment to look more closely at affective laden processes such motivated reasoning (Kunda, 1987, 1990). In our earlier studies we found some evidence that voters

[7] We also demonstrate, quite directly, the heuristic "value" of our operationalization of heuristic use. For example, voters employing an ideology heuristic make more accurate assessments of candidate issue positions, *even in the absence of any specific knowledge* of those issue stands.

were more positive in their evaluations of liked candidates for whom they learned negative information, than those for whom all they learned was positive (Redlawsk, 2002). More recently we have identified ways that memory is enhanced or conditioned by affect (Redlawsk, Lau, and Civettini, 2006; Civettini and Redlawsk, forthcoming) and are looking at how long polarization might go on before voters begin to re-evaluate and more accurately update their priors (Redlawsk, Civettini, and Emerson, n.d.) Other work using dynamic process tracing examines cognitive processing and aging (Lau and Redlawsk, 2008) and the role gender of candidates and voters plays in information processing (Redlawsk and Lau, 2008). The methodology is extremely flexible, allowing us to examine many different questions, the common thread of which is the examination of evaluation and choice as information flows over time.

V. Revising the Dynamic Process Tracing Environment

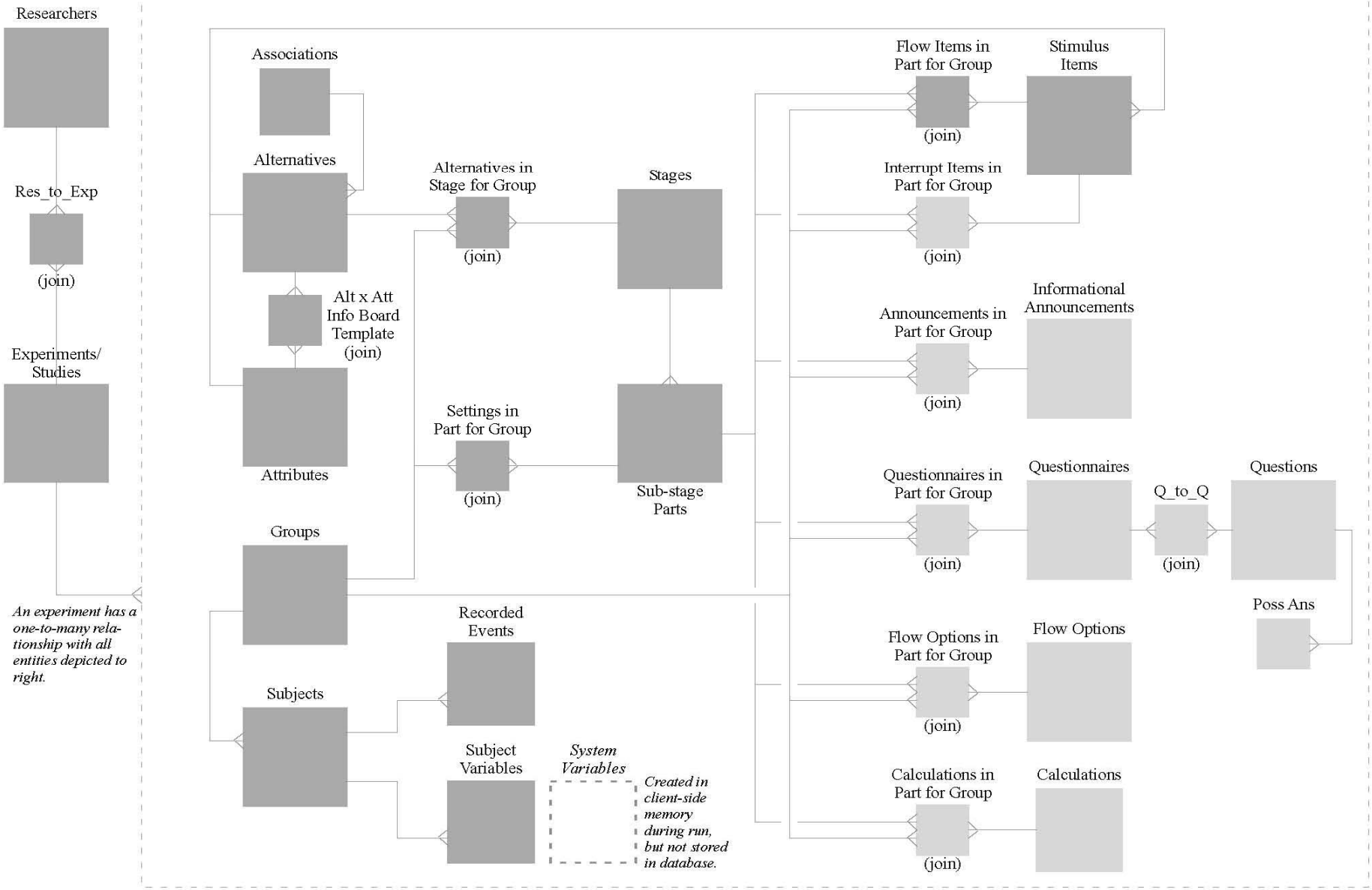
The problem with our system as it stands, however, is that we cannot easily share it with anyone else. The software that drives the system was developed over several years on an *ad-hoc* basis and was never made particularly "user friendly" even for our own use, much less for sharing. As we have presented results from studies using dynamic process tracing, we have had numerous requests for the program from other political scientists and psychologists – both U.S. based and international – which we have not been able to provide. Given this experience, we believe there is a potentially large demand for such a program, not only among political scientists but also among researchers from a wide variety of behavioral disciplines.

We have been successful in seeking funding from the National Science Foundation to rectify this situation. Taking advantage of recent advances in computer technology and software, we are nearly finished with the initial development of a new web-based system that will allow other researchers to use our dynamic process-tracing environment (DPTE). This system will make it relatively easy to accomplish a set of standard experimental tasks and allow researchers to devise additional manipulations to study dynamic decision processes. Once complete, we will publicize this new research tool, making it and an associated user manual freely available to others in the scientific community.

Figure 2 presents a schematic overview of the redesign of the system. Its modular nature allows us to make parts of the system available as they are completed. The core is an experiment development area, where researchers can build experiments through a web-based interface where each part of the experiment is specified – the alternates across which evaluations and decisions are made, the attributes of each of the alternatives, and groupings that the alternatives might fit within (such as multiple candidates within a political party). Stimuli can be created and attached to attributes and alternatives either directly, or based on defined parameters during the run of an experiment. The stimuli a subject encounters can be text, image or video or any combination (and we anticipate adding audio items at a later date). The stages of the decision can be made flexible, and each stage can have a series of substages defined in which experimental manipulations can be established. In addition, questionnaires can be defined and deployed before, during, and after the dynamic information board.

The system includes two basic subsystems: the user interface (also known as the DPTE Player) and the experimental design environment. Basic functionality includes the ability to create new or easily modify existing experiments, and automatic storage of experimental data in a structured database. Future plans include creating standard decision processing variables with the system, so that the researcher gets not only detailed subject data, but a pre defined set of variables about each subject's decision making process. Until that part of the system is complete, researchers can use the raw data to create these measures themselves. At the same time, users of the system will be able to define their own experimental manipulations. A very important part of the original system that has been enhanced in this new environment is the ability to collect online information about subjects and to use those data to define the decision environment "on the fly." For example, in an election context, we can collect political attitudes from subjects before the experiment, and then actually define the candidates and their positions during the election based on the subject's preferences. This allows very complex and subtle manipulations of the information environment in a way simply not possible with any other instrumentation available to social decision making researchers.

Figure 2 DPTE Database ER Diagram



Experimental and User Interface Design

Our development team has designed an interface that allows users to create or edit an experiment over a web-based interface. An "experiment generator" subsystem is the engine that starts the experiment. This engine makes use of an "experiment metadata" database containing all contextual data and experimental manipulations required to run a dynamic process tracing experiment, including pre-experiment/post-experiment questionnaires. These data (which can be text, image, and/or video) are developed and entered through a user-friendly interface by a research team planning an experiment. The program includes a questionnaire module for asking questions and recording answers, that can be utilized for both pre-experimental data gathering (i.e., pretest questionnaires) and for recording the dependent variables after some experimental manipulation. This module initially has some standard question types, like scales and sliders, along with multiple choice and text entry formats. We anticipate expanding on this and developing a branching mechanism to move between questions based on responses to earlier questions. Ultimately the time from displaying a question to the answer being given by the subject will be recorded as well.

The basic guts of the DPTE system are a set of "boxes" that scroll down the computer screen and provide links to other information as with the current system, as in the original version displayed in Figure 1. The experimenter can control the rate of scrolling for each sub-stage in the experiment, so information can come more quickly or more slowly as defined in the experiment. The labels on the boxes and certain other aspects of their appearance (e.g., color) are under the researcher's control, as of course is the content of the information that is linked to each box. Most importantly, the program allows the researcher to control/manipulate the information that appears in the scrolling boxes in the first place. Of course every action a subject takes and every mouse click is timed and recorded.

The system is being designed to support a range of experimental manipulations. For example, in various studies we have manipulated the number of candidates (alternatives), candidate gender, distinctiveness of the candidates, the flow of information, and initial instructions designed to place

subjects into processing or affective states. The system is to be made flexible enough to present not only "candidate" information, but essentially any arrangement of alternatives and attributes that might be part of a decision task. This is a key point. The system is not limited to looking at political campaigns, but instead any decision making process that has at its core the coming and going of information, and is either a single stage or multi stage in nature can be mimicked with this system.

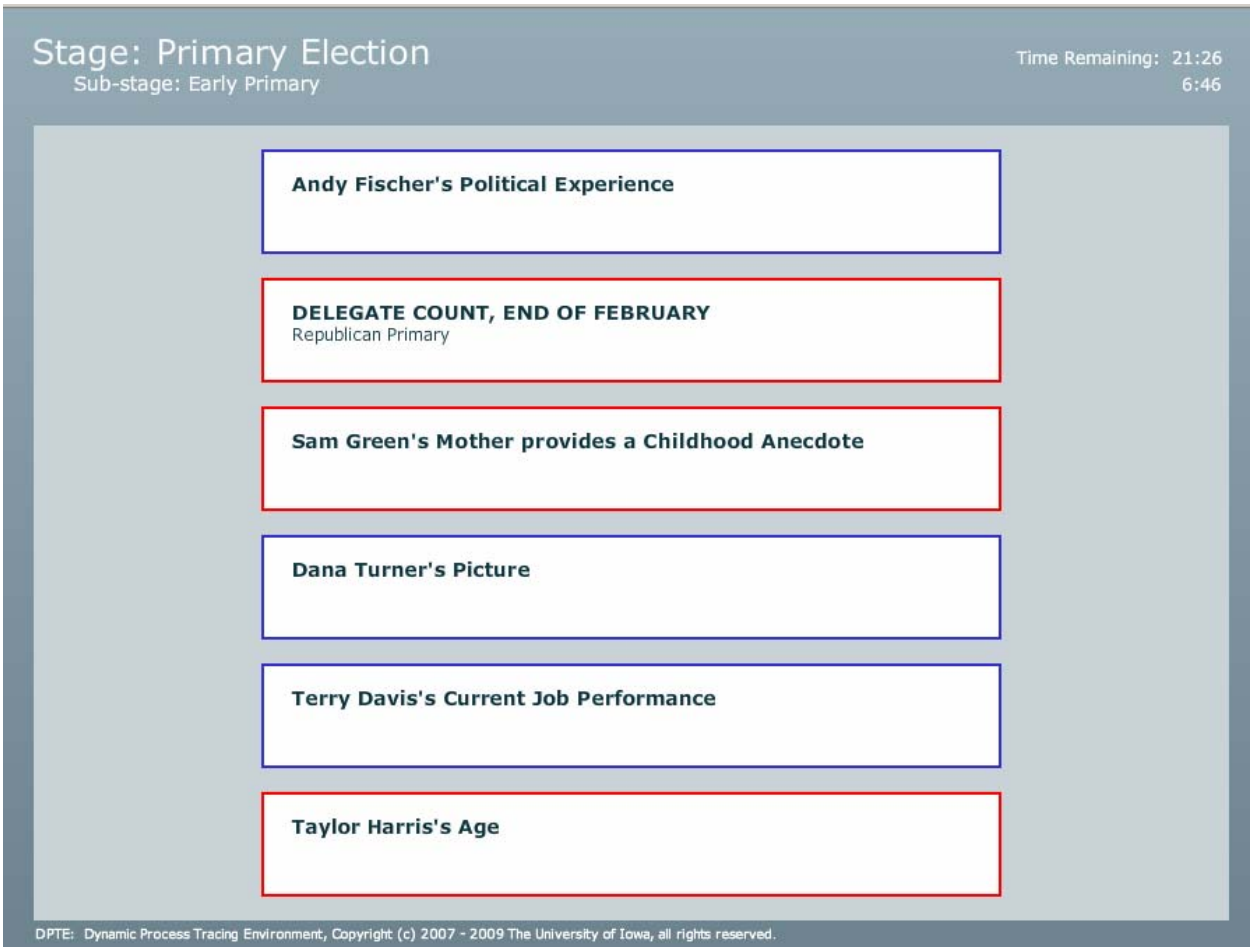
Data generated by the system includes both subject level data – whatever questions are asked fo the subject before, during, and after the experiment - and item level data, that is, data about each piece of information available to or accessed by the subject, for each subject. Such data includes what item was accessed, time of access, length of access, and other information that is unique to each piece of information a subject accesses. These data are presented in database form which can be exported to any one of a number of tools and statistical packages. In addition, users with SQL query writing expeirnece can directly access the database with sophisticated queries.

VI. Some Screenshots of the new DPTE System

Subject Interface: The DPTE Player

As of the writing of this paper we have begun beta testing the new software. We have to date run 35 subjects successfully through the system, using many of its features. There remain some bugs to address, but we anticipate making the system available to interested researchers for at least initial testing by the end of 2009. To give some sense of how the system will be viewed by researchers designing experiment, and by subjects participating in the experiments, we have included several screenshots of the new system. Figure 3 is the DTPE "Player". The Player is the screen that subjects see and with which they interact in searching for information.

Figure 3: DTPE Player Screen



This screen is the replacement for the screen shown in Figure 1, operating the same way as new information tags appear at the top and scroll down to disappear at the bottom. In addition to simply looking cleaner and more modern, it provides more flexibility than the original system. Experiments can be designed that include images associated with the text "tags" on this screen and can choose whether the tags simply consist of a "headline" or also include some additional guiding text. Like the original system this screen provides an indicator of the remaining time and the current stage of the decision cycle (in this case, "Primary Election". Note that in this example the candidates are fictitious, which is our standard approach to our studies. Note too that different boxes are bordered in different colors, under the control fo the experimenter, in order to allow a sense of "grouping", such as by party, or a quick heuristic for the

subject about which information is for which party's candidate. The boxes on the screen are clicked with the mouse to reveal the information behind them, which can be text, video, or image information.

The DPTE Player can also present "announcements" and "questionnaires" which can be done before, during, or after the main body of the scrolling items. Figure 4 shows an example of an announcement screen, which can make use of multiple fonts, sizes, and colors, and can be one or more pages and Figure 5 shows a questionnaire from a questionnaire.

Access to the DPTE Player is through a browser, with all major browsers supported. The technology uses "Flash" as its underlying driver, so subject computers will need the latest version of the flash player which is readily downloaded. An experimenter can provide subjects with a URL in order to access the system.

Figure 4: An Announcement in the DPTE Player

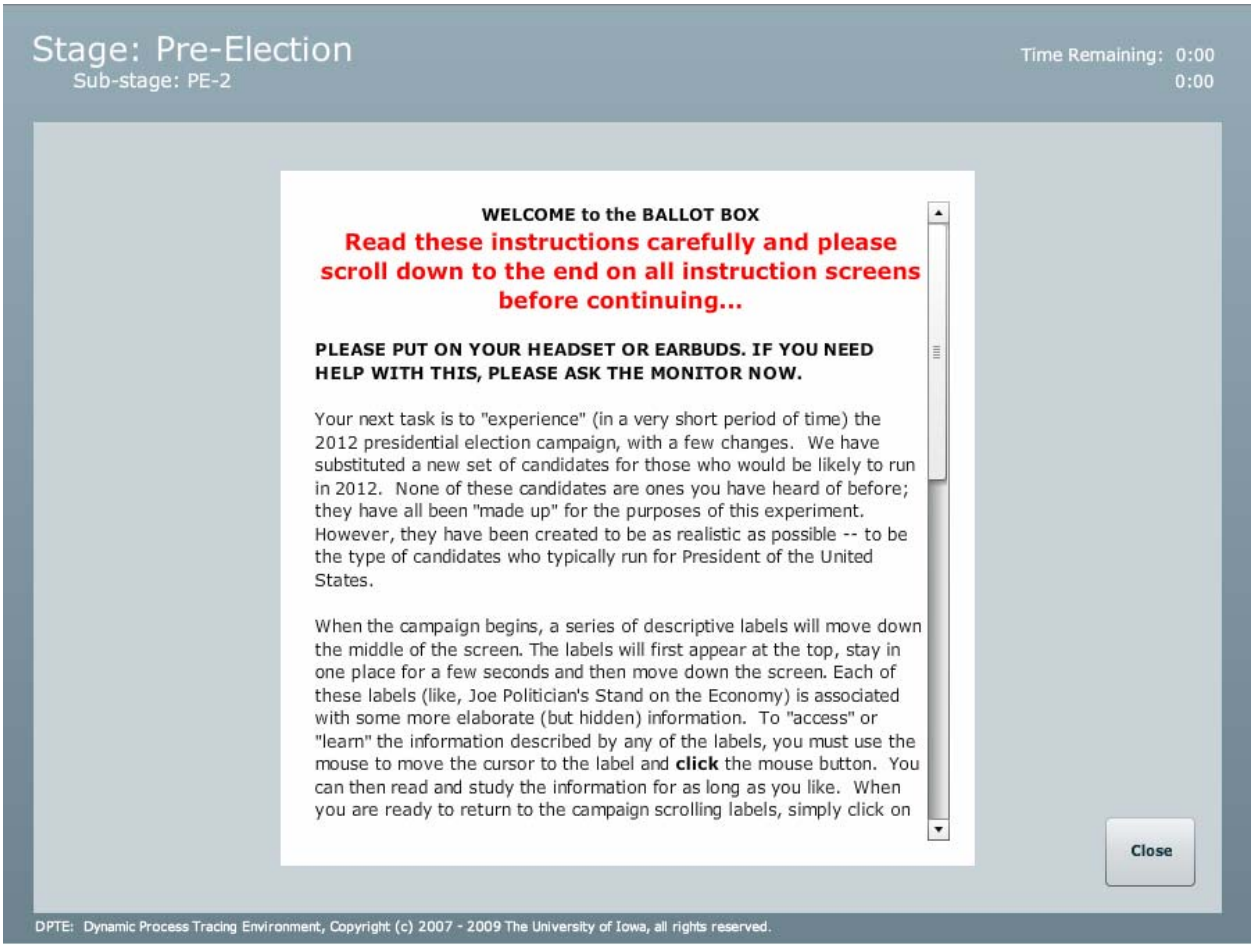
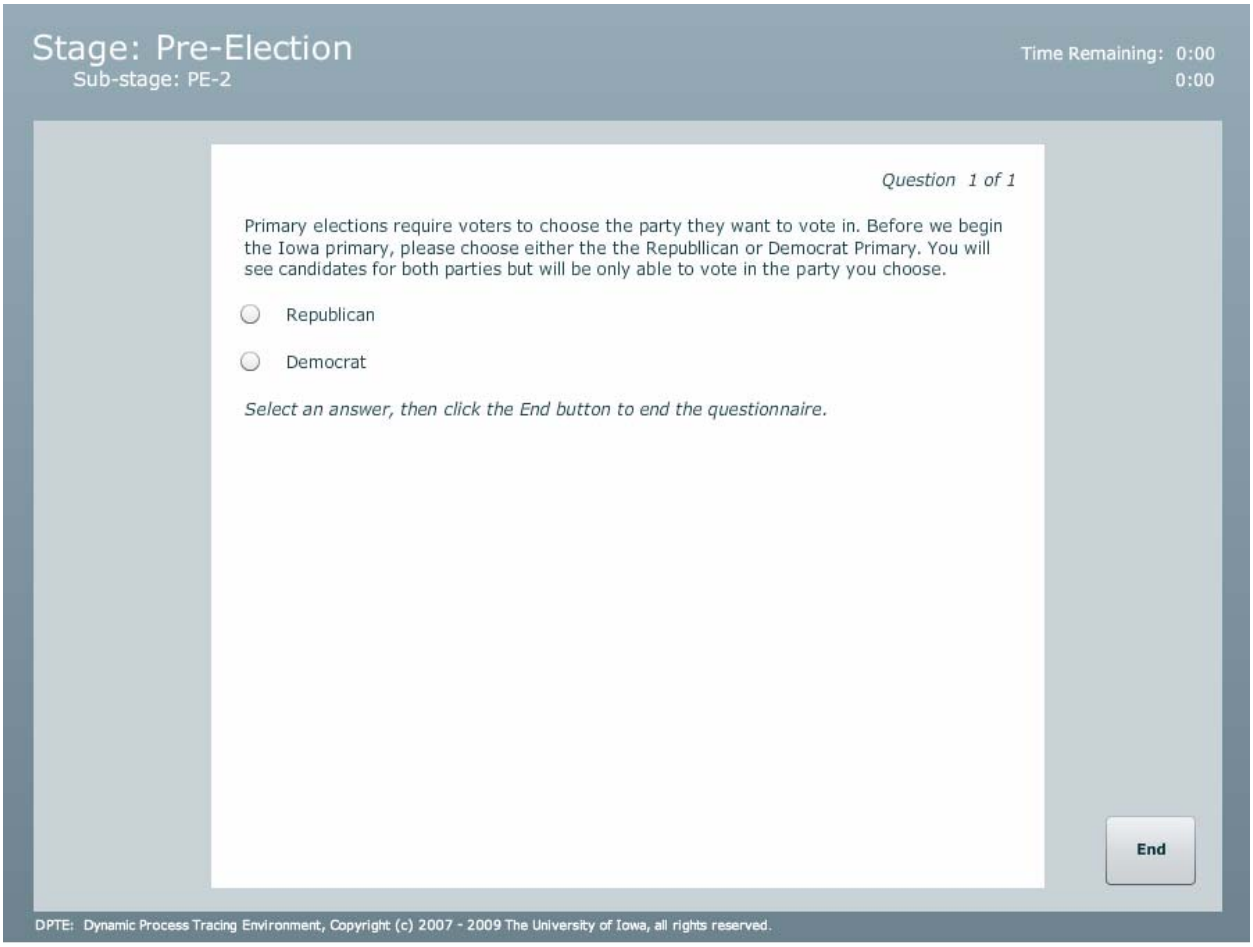


Figure 5: A DPTE Question Item



Note that the system can act on the responses to a question. In this example, we ask the subject which political party they are affiliated with for a primary election. We then later use the response tot his question to define which candidates are available to the subject during the election and which ballot they see at the end of the election.

When a subject clicks on one of the boxes on the main player screen (Figure 3) the appropriate information – which may be text, video, pictures, or eventually audio – appears on the screen. Figure 6 shows a text item, while Figure 7 shows a video item. As these items appear, the system tracks how long they are viewed and the order in which they were chosen. The researcher controls the content of these

screens, and can in fact design them to be modified "on the fly" subject to particular experimental manipulations. For example, if candidate gender is to be manipulated, the personal pronouns "he" or "she" will be manipulated automatically. Likewise the actual stands taken by a candidate can be manipulated so that a candidate's positions can be closer or further away from the subject's own preferences. Moreover, questions can be placed at any point in the process so that after viewing an item, for example, a subject can be asked about that item before returning to the main player screen. The answers to these questions can be made to condition information that subsequently becomes available during the decision process.

Figure 6: A DPTE Text Item

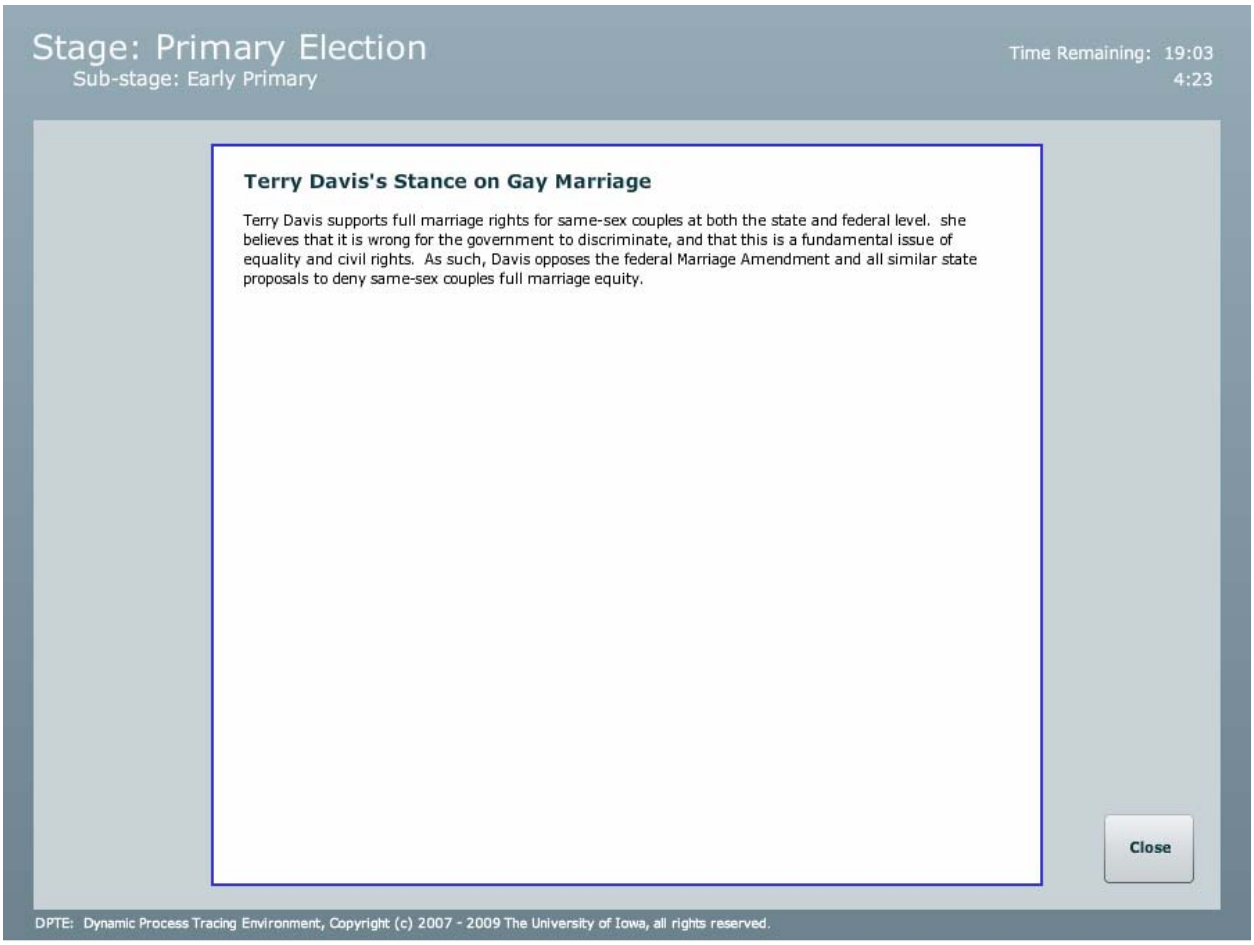


Figure 7: A DPTE Video Item

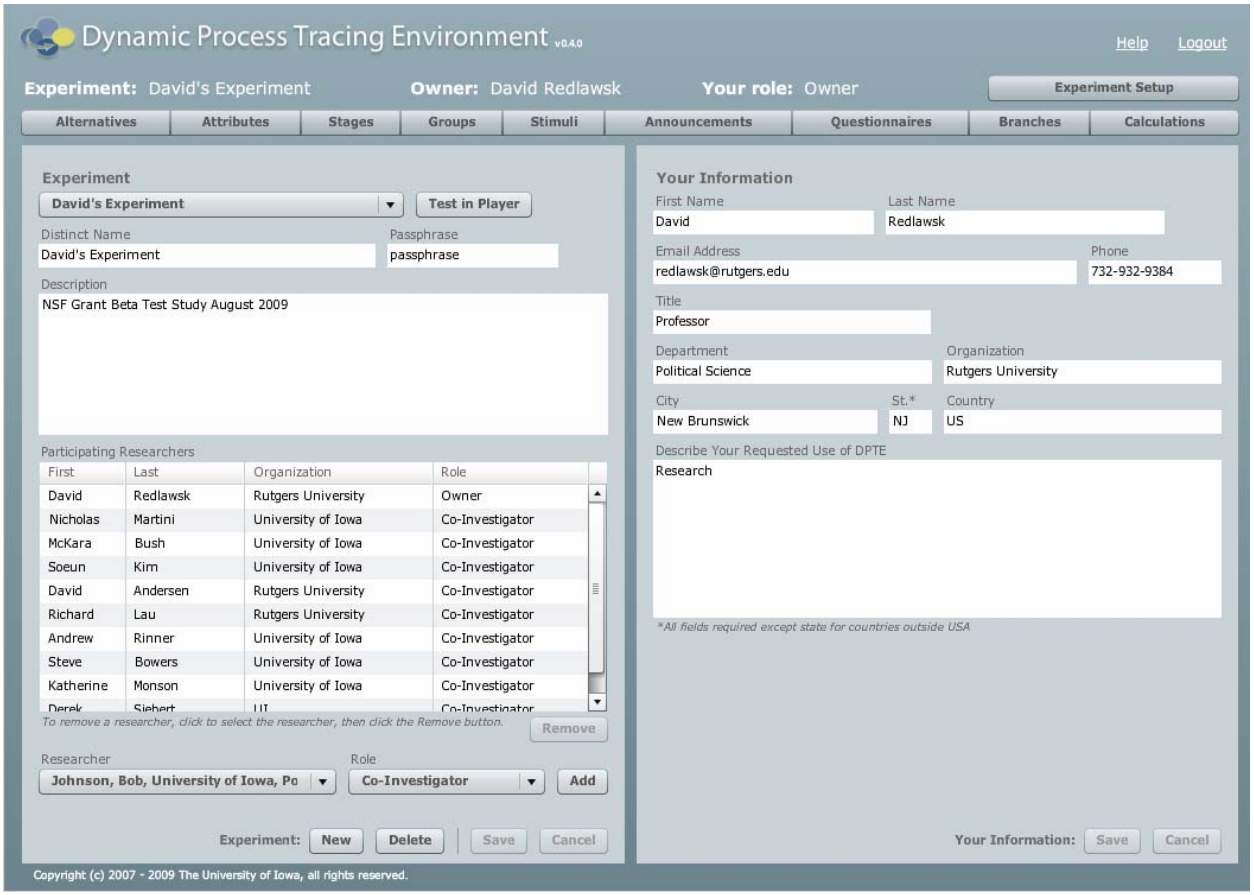
Designing an Experiment

The player screens look deceptively simple, which is what makes the system easy for subjects to use. However, the researcher development environment provides a high level of flexibility in designing experiments to examine a wide range of decision making tasks. The most important thing for the researcher is that there is a consistent look and feel to how to build an experiment, no matter which part of the experiment is being worked on. The first step is to design the parameters of the experiment – the alternatives and attributes for the decision to be made, as well as any stages that exist in the decision to be studied. For example, an election may consist of two stages, one called the "nomination context" and the other the "general election". Each stage can have a different number of alternatives available as well as

different attributes for those alternatives from which the subject will choose. Stages may also have any number of sub-stages. For example, we might design a “nomination contest” with sub-stages representing different months, or different events. Each sub-stage may have as much or as little information available to the subject as the researcher desires.

Figure 8 shows the initial experiment definition screen. Note that the owner of the experiment can give access to it to other researchers at various levels. This facility allows more than one person to work on the design phase of the experiment, while maintaining a level of control over it. Everything is secured through password protection and in order to get an account to use the system, a research will have to apply online. The main screen also provides a button hat allows the designer to test the design in the DPTE player before deploying it for real subjects.

Figure 8: Experiment Setup



Once the experiment setup is established, the designer uses the buttons across the top to develop the experiment. Since the concept is the information board, it is assumed that all experiments will have one or more “alternatives” and one or more “attributes” to present to the subject. These are each defined on its own screen. In our examples, the alternatives are political candidates and the attributes are are topics of information available for the candidates. Attributes can be assigned to specific candidates before the study, or they can be assigned dynamically, based on the ideological position of the candidates and the attributes to be assigned. This functionality allows the experimenter to design an experiment where candidates’ positions are conditioned on responses of the subjects to a pre-election questionnaire, and thus candidates can take positions that are contingent on some subject manipulation.

Stimulus items are at the heart of the experiment. A stimulus item is the detailed information that is seen when the subject clicks on a box in the DPTE Player. These items can be conditionally assigned to attributes and candidates are unconditionally assigned, as in our example in Figure 9. Here we have a candidate’s position on abortion, and it has been pre-assigned to candidate “Anderson”. The position is defined with a liberal-conservative rating of 2.29 on a 1-7 scale, which tells us it is a pretty liberal position. Note too that the text of the item has “tags” in it that allow dynamic insertion of name and gender in the item. Figure 9 is a text based item, while Figure 10 shows the definition screen for a video item. Videos – which have to be created outside the system – can be used at any point in the process of providing information about alternatives. Videos can be items that are clicked on, or can appear (as can any other item) automatically at a set time in the decision process. Note that videos can be tested within the system to ensure that they work, but they must be loaded to a video server that the subject’s computer will have access to when running the experiment. Here our video is a 20 second campaign ad from “Taylor Harris” bit it could just as easily be a five minute (or any length) video designed to distract from other information or to enhance it. We currently use a three minute video of a national convention to provide spacing between our primary election and our general election.

Figure 9: Defining a Text Based Stimulus Item

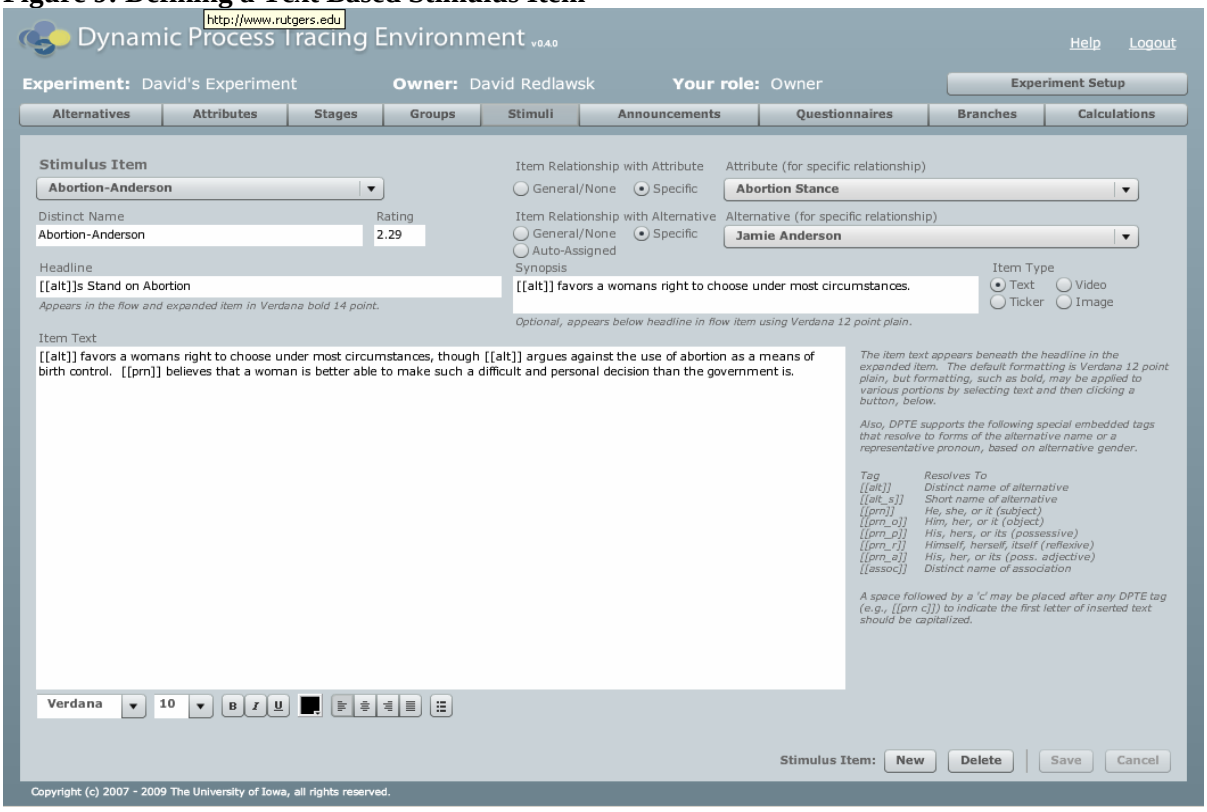
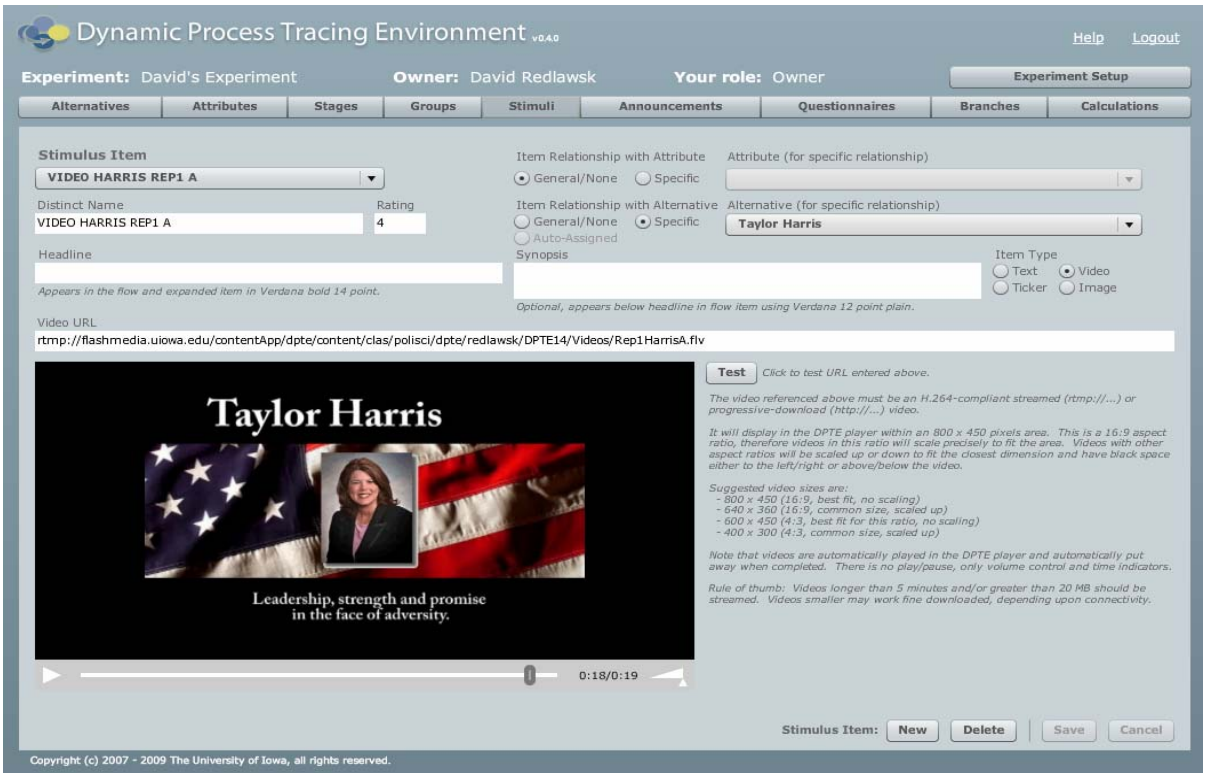


Figure 10: Defining a Video Item



Once alternatives and attributes have been defined, and the stimuli to be used in a given experiment have been created, the decision stages can be defined. Stages allow a decision environment to flow over time and to have multiple parts. In our example we have a primary election followed by a general election. Before the primary, we have a "pre-election" stage where we present an initial questionnaire and provide the subject with information about the study through announcements. This "pre-election" stage is static – that is, while it sues the player to present the information, it does not have any items that scroll down the screen, which we call "flow" items. The logic of the process is both simple and flexible. Any DPTE experiment contains STAGES and SUBSTAGES. Within the SUBSTAGES, the experiment may include any combination of BEFORE ITEMS, FLOW ITEMS, AFTER ITEMS, TIMED ITEMS, and (in the future) FOLLOW-ON ITEMS. The use of these various items is what defines what the subject sees when the Player is run. All experiments must have at least one STAGE, and a stage must have one substage, but can have as many as desired. There can also be as many stages as desired.

The various ITEMS are the stimuli defined earlier. The item type defines how the stimulus is presented. A BEFORE ITEM comes ahead of any other item in a give substage. As with most items, the way they appear in the Player is defined in chronological sequence if there is more than one. A FLOW ITEM is what the Player presents when items are scrolling down the screen for the subject to choose. Once defined, flow items are presented in random order within a substage. AFTER ITEMS are presented in the Player once all before and flow items have been presented. As should be obvious, TIMED ITEMS can be presented at a pre-defined time on the clock and will take over the screen without any action on the part of the subject. Like all items except flow items, they do not appear in the scrolling boxes. Finally, a later version of DPTE will present FOLLOW-ON ITEMS which are items that can be linked to a flow item and defined to appear at some point after a the flow item appears. In most cases, any kind of stimulus can be defined as any of the item types for presentation in the Player.

Following is an example of the logic of a DPTE experiment.

LOGIC OF A DPTE EXPERIMENT (Political Campaign Example)

STAGE: SUBJECT DATA

SUBSTAGE: WELCOME
BEFORE ITEMS
Welcome Announcement

SUBSTAGE: QUESTIONNAIRE
BEFORE ITEMS
General Attitudes Questionnaire
AFTER ITEMS
Instructions Announcement
Scenario Announcement

STAGE: PRIMARY ELECTION

SUBSTAGE: PRE-PRIMARY
BEFORE ITEMS
Partisan Identification Questionnaire
Branch based on response to questionnaire
(Branching to which group of candidates are to be available)

SUBSTAGE: EARLY PRIMARY
FLOW ITEMS
Stimuli for the candidate/attribute combinations
TIMED ITEMS
Videos that appear at specific points in time

(This logic is repeated for the Mid and Late Primary stages)

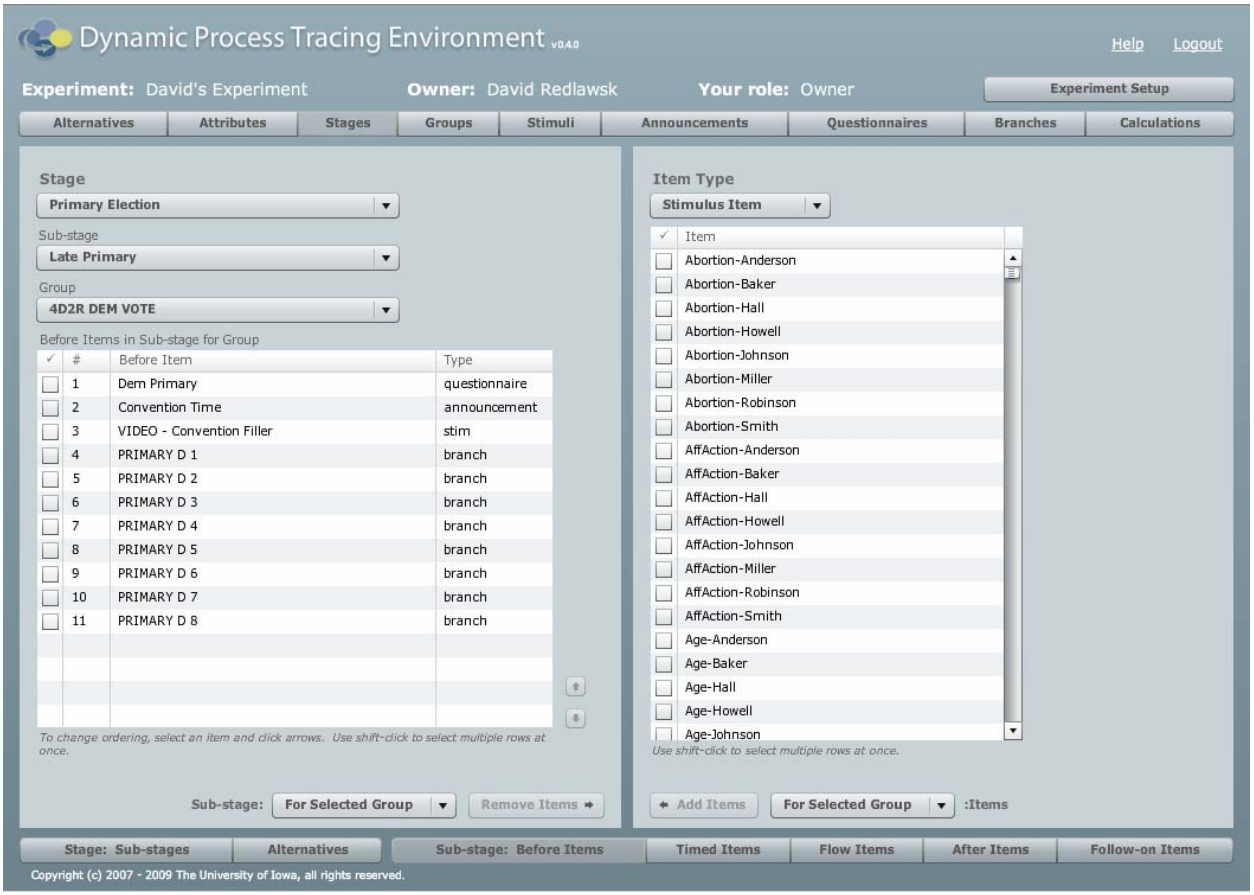
SUBSTAGE: POST-PRIMARY
BEFORE ITEMS
Election Ballot Questionnaire

AFTER ITEMS
Convention Video
RANDOM branch to specific general election combination

STAGE: GENERAL ELECTION
(This stage proceeds in a similar way to the primary. At the end, another questionnaire is presented to collect information on the subject's response to the experiment. Then a final announcement screen is presented to thank the subject and end the experiment.)

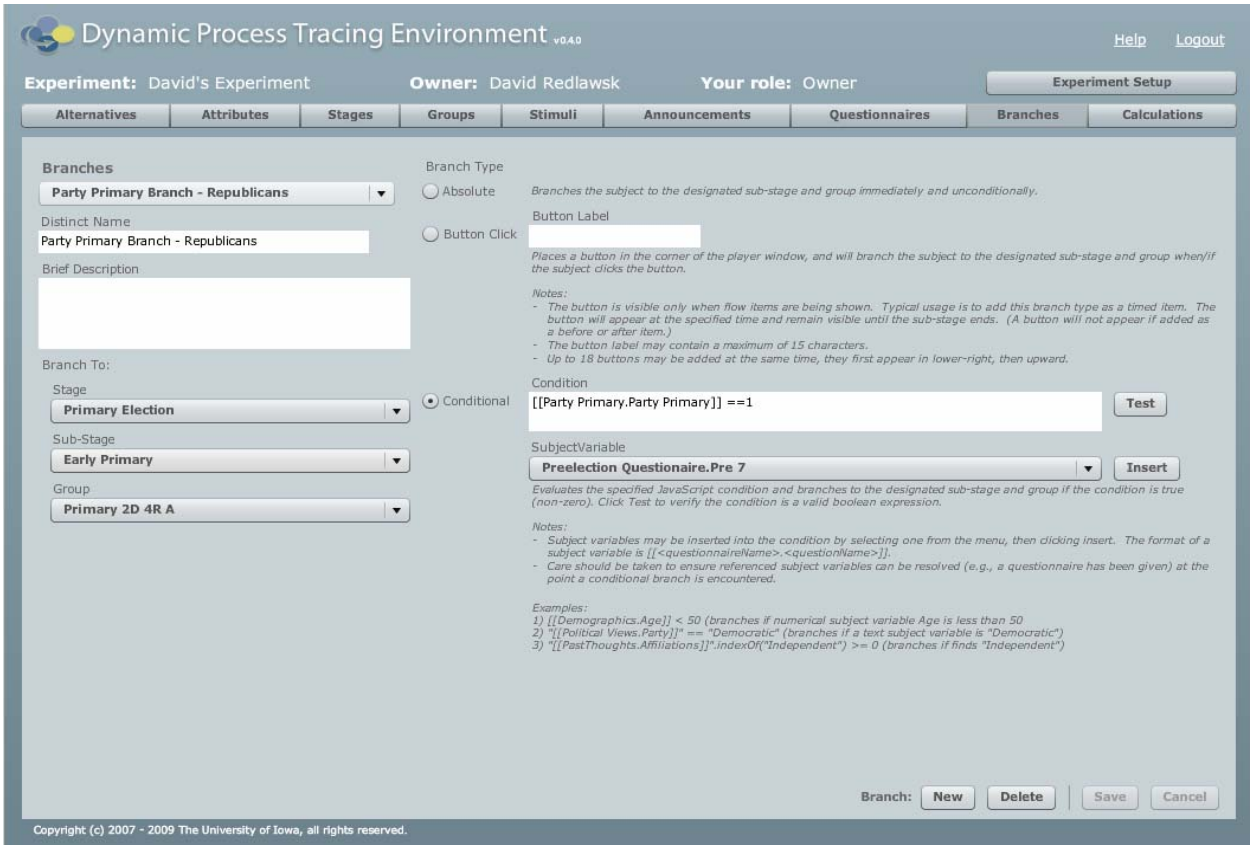
Figure 11 shows the screen sued to set up before items. This screen is virtually the same for after items. All available stimuli appear on the right side of the screen. While stimuli items are currently showing, one can also use announcements, questionnaires, and branches at any point in the before items. On the left side is the structure of before items for an experiment. Note these items will be presented to a subject in the PRIMARY ELECTION STAGE in the LATE PRIMARY SUBSTAGE. Further, the subject has to have been assigned to the 4D2R DEM VOTE group to get this set of items. This assignment was made by a questionnaire before the primary began asking the subject for their party. Groups can be defined in any way the experimenter wishes and should be thought of as the experimental conditions opr manipulations. In this case the subject saw information for 4 Democrats and 2 Republicans during the primary campaign, though the subject is voting in the Democratic primary.

Figure 11: Organizing Before Items



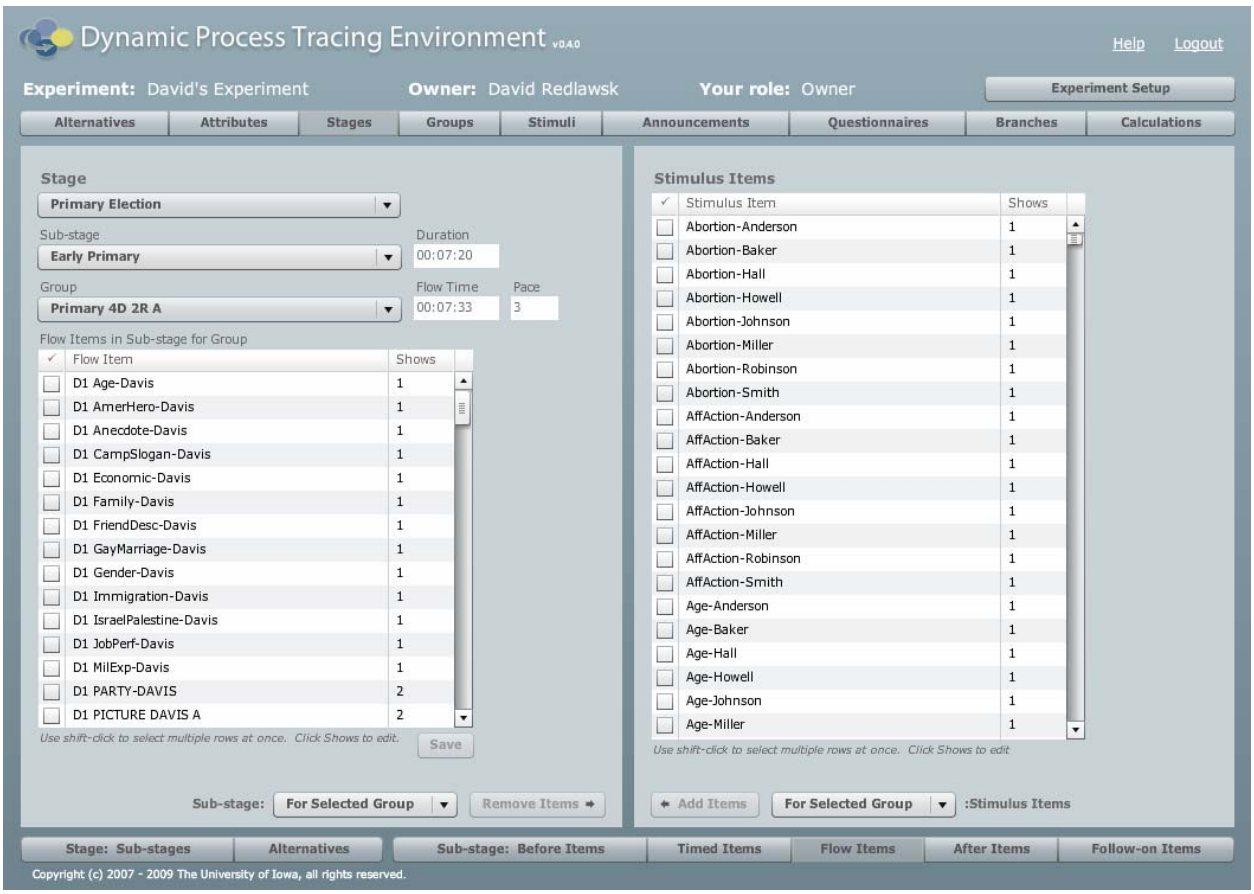
Any subject in this group will see the following when they reach this point in the substage. First, they will get the Dem Primary questionnaire, which here is the primary election ballot. Following they will see an announcement that it is time for the national convention, after which a convention video will display. It will appear on the screen and the subject will not be able to close it. When it is over it will close automatically. Following the video one of the defined branches will be activated, depending on who the subject votes for in the primary. A BRANCH allows the use of a calculation to determine which group a subject should be in. Branches may be absolute or conditional and may be based on calculations using responses to questionnaires or can be randomly assigned. In this case the branches use both response to the question and a random process to assign subjects to a general election in which the candidate they preferred in the primary may or may not be running (this is the randomized part). Figure 12 shows the screen used to define a branch.

Figure 12: Defining a Branch



The core of the process tracing system is the flow item – the boxes that scroll down thee screen on the Player present the flow items to the subject. The subject clicks on the box to get the more detailed information behind it. Defining which flow items will appear in which stage:substage:group of an experiment is done on the screen shown in Figure 13.

Figure 13: Organizing Flow Items



Note again that like before items (and after/timed/follow-on) flow items are defined for a particular Group in a particular substage in a particular stage. So if there are three experimental groups within a substage, the flow items (and other items) must be defined for each group. This provides substantial flexibility since differing experimental groups can see different information. The system automatically shows how long

the substage will run based on the number of flow items, the pace (in seconds) that the items flow down the screen, and the number of times (shows) that each flow item appears. Note this is all definable in the design of the experiment. The left side of the screen shows the items that have already been defined for this group/substage/stage. The right side shows the available items for assignment. Unlike the before items, only stimulus items may be assigned as flow items that subjects can choose.

VII. Conclusion

There is much more to the system details than can be presented here. Once the system is made available there will be a set of user documentation that should provide guidance in developing experiments. At that time the system will be made available to interested researchers. Please feel free to contact the author of this paper at redlawsk@rutgers.edu for more information or to be placed on a list of interested people for announcements of the system's availability.

Our goal is to create a new research tool that will allow behavioral researchers to conduct sophisticated computer-based experiments on human decision making and social behavior in dynamic settings without devoting years to acquiring the requisite programming skills. We have seen that the prototype system we have developed and used has resulted in significant new insights into voter decision making. The next logical step is to make an enhanced system available to any researcher interested in pursuing a wide variety of decision making questions about the dynamics of human behavior. As of the writing of this paper (August, 2009) the programming work for a first version of the DPTE system is nearly complete and is undergoing testing. We intend to use the system to carry out a study that will both be a substantive addition to our earlier studies and a comprehensive test of the new software. Once we have validated the software this way, we will make it available to researchers who wish to use it, at no charge. It is our belief that while we began this project focused on how voters use information to evaluate candidates and make a voting decision; a much wider array of studies can be carried out using the DPTE methodology. Examples include studies of decision making in times of crisis, studies of the effects of information sources and credibility, studies of public policy debates and referenda, and many others. The

key point of this methodology is to provide an experimental environment in which decision makers encounter information that comes and goes over time, make active choices of what information to examine and what to ignore, and ultimately choose between alternatives, or perhaps make no choice at all. Our hope is that this new methodology will enhance the ability of those doing behavioral decision making research to test hypotheses about how people process information – cognitively and emotionally – over time.

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