Institute for Science Technology and Public Policy
The Bush School of Government and Public Service
TEXAS A&M UNIVERSITY

A nonpartisan, interdisciplinary public policy research institute.

Decision Making Under Conditions of Uncertainty: Experimental Assessment of Decision Models

March 31, 2003 – March 31, 2005

This research was funded by the National Defense University
Contract No. DABJ29-03-P-0084

INSTITUTE FOR SCIENCE, TECHNOLOGY AND PUBLIC POLICY
George Bush School of Government and Public Service • Texas A&M University • College Station, TX 77843-4350
phone: (979) 862-8855 fax: (979) 862-8856 avedlitz@bushschool.tamu.edu

Principal Investigator

Arnold Vedlitz, Ph.D. • Institute for Science, Technology and Public Policy, Bush School

Co-Principal Investigators

Alex Mintz, Ph.D. • Deparment of Political Science, Texas A&M University
Letitia T. Alston, Ph.D. • Institute for Science, Technology and Public Policy, Bush School

Collaborators

Steven B. Redd, Ph.D. • Department of Political Science, University of Wisconsin-Milwaukee
Mark K. Davis, Ph.D. • National Defense University
Roger Channing, Ph.D. • National Defense University

Research Scientists

Xinsheng Liu, Ph.D. • Institute for Science, Technology and Public Policy, Bush School

Research Funded By

The National Defense University, Grant No. DABJ29-03-P-0084

Additional Support Provided By

The Institute for Science, Technology and Public Policy

George Bush School of Government and Public Service • Texas A&M University • College Station, TX 77843-4350
phone: (979) 862-8855 fax: (979) 862-8856 avedlitz@bushschool.tamu.edu

Research Support

This research was supported by the National Defense University under Contract No. DABJ29-03-P-0084 and was a project of Texas A&M University's Institute for Science, Technology and Public Policy in the George Bush School of Government and Public Service, Texas A&M University.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Defense University.

Report Citation

Arnold Vedlitz, Alex Mintz, Steven B. Redd, Xinsheng Liu, and Letitia T. Alston. *Decision Making Under Conditions of Uncertainty: Experimental Assessment of Decision Models*. (March 2005). A report to the National Defense University by the Institute for Science, Technology and Public Policy in the George Bush School of Government and Public Service, Texas A&M University.

FIGURES PAGE

TABLES PAGE

Executive Summary

INTRODUCTION

Senior Department of Defense leaders make numerous decisions about the appropriate utilization of complex scientific and technological innovations. These decisions are especially problematic because of the difficulty in assessing risks, benefits, costs, and unintended consequences of these new discoveries. However, decisions related to the proper investment, implementation, and deployment of technological innovation must be made, even if they must be considered under conditions of uncertainty by decision makers with only limited information and scientific expertise.

The challenge is, therefore, to make the best possible decision with the best information available, using the best decision-making technique possible, even in the face of limited information and uncertain outcome. The purpose of this study was to increase our understanding of how, under conditions of limited information and uncertainty, the framing of scientific and technological information influences decision making. If we understand the decision processes that key decision makers undergo in assessing choices under uncertainty, we can help structure conditions that maximize their ability to access the types of information they really need to make the best decisions in real settings.

While we looked specifically at how individuals, in an environment of uncertainty, make decisions on the application of scientific and technological innovation to one problem, we were primarily interested in understanding the dynamics of decision-making involving the application of science and technology to problem solving and choice making generally. Once this is known, organization leaders can work to provide the structure set of decision tools that will facilitate information retrieval and utilization and that decision makers need to grapple with large amounts of sometimes conflicting information. In this project, we sought a general understanding of the decision processes individuals engage in as they seek to apply technological innovations to a particular problem. The context we set up to arrive at this understanding was the choice of what technologies to employ in a set of specific scenarios regarding the war on terror.

RESEARCH OBJECTIVE

The purpose of the study is to increase our understanding of how, under conditions of limited information, the factors of uncertainty and the framing of scientific and technological information influence decision making about the appropriate utilization of complex scientific and technological innovations.

The experiments used in this project were developed around the choice of new technologies in a set of scenarios regarding the war on terror. Experiments were designed to enable researchers to examine the ways decision makers choose from among three categories of antiterrorism technologies or do nothing under different conditions of certainty and framing.

THEORETICAL FOUNDATION

The poliheuristic theory of decision making was used as the basis for the study. The poliheuristic theory incorporates the conditions surrounding policy decisions, as well as the cognitive processes associated with these surroundings. It posits that decision makers employ a two-stage decision process: in the first stage, decision makers screen available alternatives utilizing cognitive-based heuristic strategies; in the second stage, when the decision matrix has been reduced to a more manageable number of alternatives and dimensions, decision makers resort to analytic, expected utility, or lexicographic rules of choice in an effort to minimize risks and maximize rewards (Mintz and Geva 1997; Mintz et al. 1997). The poliheuristic theory also posits that different decision heuristics and strategies may be employed in response to different decision tasks as a function of environmental and/or cognitive constraints.

The poliheuristic theory is based on five main processing characteristics of decision making: (1) nonholistic search, (2) dimension-based processing, (3) noncompensatory decision rules, (4) satisficing behavior, and (5) order-sensitive search (see Mintz and Geva 1997; Mintz et al. 1997). For the purposes of this project we concentrate on dimension-based processing, noncompensatory decision rules, and on maximizing versus satisficing behavior. A dimension is defined as the thematic basis (or criterion) underlying the evaluation of an alternative. Alternatives represent different courses of action such as "accept" and "reject." The poliheuristic theory asserts that in situations where cognitive complexity is high or in any situation wherein leaders are faced with cognitive and/or environmental constraints, decision makers will use a dimension-based process instead of an alternative-based approach for processing information. The theory also posits that decision makers 'satisfice' rather than 'maximize' utility (Mintz and Geva, 1997; Mintz et al., 1997). The difference between maximizing and satisficing decision strategies is that, in the former, alternatives are compared to one another, and the alternative with the highest utility is chosen. In the latter, alternatives are compared to a threshold, and the first alternative to meet or surpass that threshold is selected. The poliheuristic theory stresses satisficing, not only because it is concerned with finding 'acceptable' alternatives instead of maximizing ones, but also because it is possible that not all dimensions or alternatives will be considered prior to a decision being made.

PROCESS TRACING METHODS AND THE DECISION BOARD PLATFORM

Process tracing is a methodology designed to identify what information is being accessed to form a judgment and the order in which the information is accessed. Data gathered from process tracing can then be used to make inferences about which decision strategies were employed en route to a choice. To facilitate process tracing, a computerized system—the Decision Board (www.decisionboard.org/academic) was developed by Dr. Alex Mintz and utilized in this study.

The core structure of the Decision Board is a matrix of alternatives and dimensions on which the alternatives are evaluated. The computerized Decision Board records key features of the decision-making process: (a) the sequence in which decision makers acquire the information, (b) the number of items that respondents view for every alternative along every dimension, and (c) the amount of time that elapses from the time respondents begin the task until they make their choice. Using process-tracing techniques, the Decision Board also displays the "decision portraits" of decision makers and calculates maximizing versus satisficing decision rules. For this project, a policy scenario dealing with combating terrorism was used to introduce alternatives and dimensions into the Decision Board.

METHODS

Subjects

Forty-six undergraduate students at the University of Wisconsin-Milwaukee (UWM) and fifty officers at National Defense University (NDU) participated in the initial experiment. The undergraduate student subjects, who were randomly recruited from several political science courses, provided a comparison and control for the NDU sample. The officers were recruited from a leadership course taught over two semesters at NDU. The subjects were randomly assigned to one of four experimental conditions.

Design

A 2 X 2 between-groups factorial design was employed. The two factors were as follows: (1) Framing of likelihood of funding (emphasis on probability of being funded vs. emphasis on probability of not being funded), and (2) Certainty effects (certain vs. uncertain that technology will function as designed). We also measured the *choices* subjects made and *Information Acquisition Patterns*: The choices subjects made were categorized as "correct" and "incorrect" choices. Information acquisition patterns include alternative-based or dimension-based strategies, and compensatory or non-compensatory decision rules. Measures of alternative vs. dimension-based processing are calculated using Billings and Scherer's (1988) search index. The compensatory vs. noncompensatory measure comes from Astorino-Courtois (2000). We also used the noncompensatory measure devised by Mintz and Geva (1997) to verify the Astorino-Courtois measure.

The Research Instrument

A 4 X 3 (alternatives X dimensions) matrix was implemented. The Decision Board included twelve information bins, which contained information pertaining to the evaluation of a given alternative along a given dimension. The information was presented as an evaluative statement followed by a corresponding numerical evaluation. Decision makers could open any information bin by clicking on it. Subjects indicated their choices by clicking on a choice button underneath the corresponding alternative. Each subject dealt with only one of the four following conditions: positive framing-certain technology, positive framing-uncertain technology, negative framing-certain technology, and negative framing-uncertain technology.

Experimental Manipulations

In order to determine the influence of the importance of advisers and the order of their appearance in decision processes and to determine the influence of decision processes on choice, two factors were examined: framing and uncertainty.

Manipulation of Framing

Subjects in the positive framing condition were told, "At the present time, because of the war on terrorism, there is approximately a 90% chance that Congress will fund at least one of these options. Congress has committed verbally and in writing to do whatever it takes to protect the American public from terrorism." In contrast, those in the negative framing condition were told, "At the present time, because of the recent war in Iraq, there is approximately a 10% chance that Congress will not fund any of these options. Congress may be constrained in its spending because of a weak domestic economy and the ongoing war in Iraq and the cost of the war approaching $100 billion."

Manipulation of Certainty

Subjects in the certain condition were told, "At this stage there is a high level of certainty that these future technologies will be successful and will work as conceived of and designed. Many in the scientific community are encouraged by the progress made so far and are hopeful that these options and the technology associated with them will actually work." In contrast, those in the uncertain condition were told, "At this stage there is a high level of uncertainty about whether these future technologies will be successful and will work as conceived of and designed. Many in the scientific community are skeptical about the progress made so far and doubt that these options and the technology associated with them will actually work."

Since many policy decisions are made under time and informational constraints, all of the subjects were subjected to time pressure in order to increase the "mundane reality" (Aronson and Carlsmith 1968). The experimental manipulation consisted of instructions indicating that there was a time constraint. However, the subjects were not actually restricted in the amount of time available.

Procedure

The undergraduate students were administered the experiment in a computer lab at the University of Wisconsin-Milwaukee and the NDU attendees were tested via the National Defense University. Each subject operated online on a computer. The instructions and decision scenarios were displayed on the computer screen. Subjects were informed that they would be presented with a specific scenario concerning various technologies being developed to combat terrorism and with a decision matrix containing alternatives and the evaluations of those alternatives along three different dimensions: military, economic, and political. The subjects were instructed to make the best choice among the available options. Following the policy decision, a post-decision questionnaire was administered, followed by a detailed debriefing.

MAIN FINDINGS

The study yielded the following findings[1]:

1. Uncertainty affected subjects' choices. Uncertainty generally led to higher proportions of subjects making the "correct" decision as officers sought more information when there was uncertainty about the technologies. The major exception occurred for the military subjects when they were also employing noncompensatory strategies. When noncompensatory strategies were used, certainty aided the military subjects in choosing "correctly."
2. Uncertainty also affected decision makers' selection of decision strategies. Military commanders employed alternative-based procedures when faced with uncertainty.
3. Framing affected choice. In general, positive framing led to a greater likelihood of participants making the "correct" choice.
4. Military commanders tended to use satisficing strategies. This could be interpreted to mean that greater experience and familiarity with the general problem area (antiterrorism) encouraged a more realistic, compromise position among the military subjects.
5. We found a significant difference between the student and military groups in their choices of compensatory versus noncompensatory processing. The military subjects were more likely to choose noncompensatory processing strategy than the student subjects. This finding suggests that military officers resorted to the use of cognitive shortcuts to a greater degree than did their student counterparts.
6. We analyzed differences between the two groups in the number of information bins accessed and found that the military subjects tended to gather less information than the student subjects en route to choice.
7. Military commanders were very reluctant to choose the Do Nothing option while student subjects were much more likely to do so.
8. The military commanders overwhelmingly favored the Border Crossing Sensors option while the student subjects were more evenly split between Border Crossing Sensors and the Do Nothing options. It may be that the positive evaluations for that alternative for both the military and political dimensions outweighed the higher positive score along the military dimension for the Local Emergency Responder option.

[1]These results were not always replicated with the University of Wisconsin-Milwaukee (UWM) student subjects.

LESSONS AND RECOMMENDATIONS

Our research findings convey some important messages and applied lessons about how uncertainty and framing of scientific and technological information may influence decision processes and outcomes.

First, uncertainty about technological innovations is not necessarily undesirable in real decision situations as decision makers tend to seek more information when there is uncertainty about their choices. The general implication of the findings on the effects of uncertainty is that, in the case of experienced decision makers, when more information is thought to be essential for making good decisions, learning tools that stress the uncertainty of the issue are more likely to lead to the use of alternative-based information search strategies and the accessing of more information before decisions are made. This finding also has implications for the presentation of information on which decision makers act.

Second, different framing of the same decision problem do affect decision process and choice outcomes, even for seasoned decision makers. Special training and experimentation with multiple frames and deep analysis on possible choice outcomes may make decision makers more aware of the general tendency to be influenced by the way information is presented.

Third, regardless of certainty or uncertainty and positive vs. negative framing, experienced decision makers, such as the military officers at National Defense University, tend to choose "doing something" even when "doing nothing" is an option and, in fact, even when "doing nothing" is the highest rated option. Military planners may need to pay more attention to this action orientation and minimize the risk of only making action-based choices when sometimes, "doing nothing" is actually the best option.

Fourth, our study shows that as an emerging theoretical framework—the poliheuristic decision theory—may represent a viable alternative theoretical framework to the existing decision models and can be used in various education and training programs in the fields of risk management, conflict resolution, leadership, foreign policy analysis, strategic planning, and political decision making. The poliheuristic theory embodies fundamental elements of both rational and cognitive decision models and incorporates the conditions surrounding policy decisions, as well as the rational and cognitive processing characteristics associated with these surroundings.

Fifth, our study also demonstrates the potential of the Decision Board as a training and support tool for decision making on complex choice situations involving uncertainty, limited information and potential framing effects.

Finally, we recommend that future research should further explore the important issues we examined in this study, including 1) replication of these experiments to shed more light on the validity of the results; 2) further investigation of the role of uncertainty in information searches; 3) exploration of appropriate training in the influence of framing, and the role of factors such as accountability, ambiguity, and information availability.

Research Findings and Conclusions

INTRODUCTION

Senior Department of Defense leaders make numerous decisions about the appropriate utilization of complex scientific and technological innovations. These decisions can be especially problematic because of the difficulty in assessing risks, benefits, costs and unintended consequences of these new discoveries. However, decisions related to the proper investment, implementation and deployment of technological innovation must be made, even if they must be considered under conditions of uncertainty by decision makers with only limited information and scientific expertise. The challenge is, therefore, to make the best possible decision, with the best information available, using the best decision-making technique possible, even in the face of limited information and uncertain outcome.

The purpose of the study reported here and the follow-up study reported in the Appendix C is to increase our understanding of how, under conditions of limited information, the factors of uncertainty and the framing of scientific and technological information influence decision making. While this project looks at how individuals, in an environment of uncertainty, make decisions on the application of scientific and technological innovation to a specific problem, the goal is to understand the dynamics of decision making involving the application of science and technology to problem solving and choice making generally. By examining decision making behavior in a specific case, we gain general information and understanding. This information can be used by organization leaders to provide the set of decision tools that will facilitate information retrieval and utilization that decision makers need to grapple with large amounts of sometimes conflicting information.

The experiments used in this project to examine decision making were developed around the choice of technologies to employ in a set of scenarios regarding the war on terror. Since the terrorist attacks on the United States on September 11, 2001, the United States has been engaged in a "War on Terror." This war on terror has taken several forms, from a revamped warning system to military operations in Afghanistan and Iraq. Many of the initiates in the war on terror have centered on detecting evidence of terror activity and terrorist operations. These include the Terrorist Threat Integration Center (TTIC), Talon, Guardian, the Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBE), Project Bioshield, Customs and Border Protection (CBP), and the Container Security Initiative (CSI) (Redd, 2005). Moreover, numerous companies and research centers have been developing various technologies focused on helping the United States detect the presence of weapons of mass destruction. We searched the Internet and found several companies and organizations discussing various technologies for detecting the presence or "launch" of weapons of mass destruction (e.g. Biowatch, Thermo Electron Corporation). Most of these technologies seemed to fall into three basic categories, which we have labeled *border-crossing type sensors, environmental type monitors*, and more localized *emergency responders* (see also Campbell and Heilweil 2003).

Experiments were designed to enable researchers to examine the ways decision makers choose from among these three categories of antiterrorism technology vs. Do Nothing under different conditions of certainty and framing. Vertzberger (1990, 384-5) notes that uncertainty "means confusion about the meaning of environmental configurations." In this sense, uncertainty can be interpreted as a decision maker not being clear about what message any particular piece of information is conveying. Vertzberger (1990, 366), citing Scott (1982) also states that uncertainty can be thought of as the "ratio of anticipated to unanticipated consequences."[1] This definition relates more to the consequences of decision making than the nature of the information itself. We deal with uncertainty in the second sense. In the current war on terror, many of the technologies for detecting the presence of weapons of mass destruction are new and relatively untested on a mass scale. In other words, there is no guarantee that they will work as intended. We want to investigate how uncertainty influences decision making in the context of possibly using these technologies in the war on terror.

---

[1]See Castellan (1993), Hogarth (1990), Juslin and Montgomery (1999), and Svenson and Maule (1993) for further discussion of the concept of uncertainty.

Framing is the second variation manipulated in these experiments. International relations and foreign policy are replete with examples of individuals, groups, organizations, and institutions attempting to frame their policies and/or the intentions and actions of others. From President Ronald Reagan's references to the Soviet Union as the "Evil Empire," to Arab and Israeli leaders blaming each other for the continued Intifada, to former President George H. W. Bush's calling Saddam Hussein "Hitler," we can see that framing is an oft-used technique in international relations and foreign policy discourse.

Tversky and Kahneman (1981, 453) refer to a decision frame as:

> The decision maker's conception of the acts, outcomes, and contingencies associated with a particular choice. The frame that a decision maker adopts is controlled partly by the norms, habits, and personal characteristics of the decision maker.

Tversky and Kahneman (453) proceed to explain that it is quite possible to frame any particular decision in many different ways. In a similar vein, Frisch (1993) uses the term "framing effects" in reference to the experimental findings that individuals often respond differently to different descriptions of the same decision problem. According to Feldman (1995, 267-268), "frames focus attention on specific dimensions (explanations) for understanding issues . . . frames highlight connections between issues and particular considerations, increasing the likelihood that these considerations will be retrieved when thinking about an issue."

We believe that framing effects are a crucial variable in any rigorous examination of decision making in the context of the war on terror. How the options for detecting the presence of weapons of mass destruction are framed to decision makers is an important factor in determining the reasons for choice. Before discussing how these two factors, uncertainty and framing, were manipulated in our experiments we first provide a brief discussion of the theoretical and conceptual foundations of our argument.

POLIHEURISTIC THEORY

The poliheuristic theory of decision making incorporates the conditions surrounding policy decisions, as well as the cognitive processes associated with these surroundings (Mintz and Geva 1997). In other words, it concentrates on the "why" and "how" of decision making, which makes the theory relevant to both the contents and the processes of decision making. The term, poliheuristic, can be subdivided into the roots *poly* (many) and *heuristic* (shortcuts), which refers to the cognitive mechanisms decision makers utilize in attempts to simplify complex decision tasks (Geva, Redd, and Mintz 2000; Mintz and Geva 1997; Mintz et al. 1997). Abelson and Levi (1985, 255) citing Braunstein (1976) define heuristics as "problem-solving methods which tend to produce efficient solutions to difficult problems by restricting the search through the space of possible solutions." Sniderman, Brody, and Tetlock (1991, 19) state "Heuristics are judgmental shortcuts, efficient ways to organize and simplify political choices, efficient in the double sense of requiring relatively little information to execute, yet yielding dependable answers even to complex problems of choice." They further note that through the use of heuristics "people can be knowledgeable in their reasoning about political choices without necessarily possessing a large body of knowledge about politics" (ibid.).

The poliheuristic theory of decision making proposes that decision makers employ a two-stage decision process where in the first stage decision makers screen available alternatives utilizing cognitive-based heuristic strategies. In the second stage, when the decision matrix has been reduced to a more manageable number of alternatives and dimensions, decision makers resort to analytic, expected utility, or lexicographic rules of choice in an effort to minimize risks and maximize rewards (Mintz 1993; Mintz et al. 1997; Payne et. al. 1993). The first phase in the decision process typically involves a nonexhaustive search wherein decision makers process information across dimensions in an attempt to select "surviving" alternatives before the completion of the consideration of all alternatives along all dimensions (Mintz and Geva 1997; Mintz 1993). As Mintz et al. (1997, 554) state, "Often, foreign policy decisions are based on the adoption or rejection of alternatives according to one or at most a few critical criteria." Suedfeld and Tetlock (1992, 55-56) point out that human beings as cognitive managers "react to specific challenges and opportunities . . . [by adjusting] the complexity of their information processing in response to variables such as the importance of the decision, the reversibility of the decision, [and] the need to justify one's views to an audience or constituency." After this initial screening, the second phase of decision making consists of a lexicographic or maximizing decision rule used in selecting an alternative from the subset of "surviving" alternatives.[2]

Another key premise of the poliheuristic theory is its reference to the *political* aspects of decision making in policy context. The assumption is that the decision maker measures costs and benefits, risks and rewards, gains and losses, and success and failure in terms of their political ramifications above all else (Mintz 1993). Mintz and Geva (1997) note that politicians value gains and losses in political terms, and domestic politics is the essence of decision. Furthermore, politicians are concerned about challenges to their leadership, their prospects of political survival, and their level of support. Because loss aversion (Jervis 1992; Kahneman and Tversky 1979; Levy 1992a, 1992b) outweighs all other considerations, leaders are driven more by avoiding failure than by attaining success (Anderson 1983). As Mintz and Geva (1997, 84) assert, "the political dimension is important in . . . policy decisions not so much because politicians are driven by public support but because they are averse to loss and would therefore reject alternatives that may hurt them politically." DeRouen (1994, 2001) concurs by stating that a leader's perception of the political consequences of his/her policies plays a decisive role in affecting the means chosen to deal with a foreign policy crisis. The theory, then, suggests procedures for eliminating alternatives by adopting or rejecting courses of action based on this political heuristic in a two-stage decision process (Mintz et al. 1997).

The theory also posits that different decision heuristics may be employed in response to different decision tasks as a function of environmental and personal variations. This premise implies that these decision heuristics and strategies may be suboptimal (i.e., not always the "best"). A decision strategy is composed of a set of procedures "that the decision maker engages in when attempting to select from among alternative courses of action, and a decision rule that dictates how the results of the engaged-in procedures will be used to make the actual decision" (Beach and Mitchell 1978, 439-40; quoted in Mintz et al. 1997). Again, decision makers not only use different strategies depending on various environmental and/or cognitive constraints (Geva, Redd, and Mintz 2000; Maoz 1986, 1997; Mintz and Geva 1997; Mintz et al. 1997), they also resort to the use of different strategies en route to a single choice (Mintz and Geva 1997; Mintz et al. 1997; Payne et al. 1993).

The poliheuristic proposition that decision makers are flexible in the selection of a decision heuristic in a choice situation differs from one of the main propositions of expected utility theory (see Hogarth 1987; Simon 1990). Expected utility theory assumes that a single decision rule is adopted for any decision task and that this decision rule is kept throughout the entire task. Specifically, "the procedures are the computation of product sums of subjective probabilities and utilities for each alternative and the decision rule is maximization-selection of the alternative with the maximum product sum" (Beach and Mitchell 1978, 440). However, past research (see Abelson and Levi 1985; Maoz 1997; Olshavsky 1979; Payne, Bettman, and Johnson 1988, 1993) has shown that processing characteristics vary as a result of the choice environment. The poliheuristic theory specifically states that decision procedures and rules are not "fixed;" instead they vary depending on intervening variables such as one's goals, the domain in which a decision maker operates, and other situational constraints (Mintz 1997; Mintz et al. 1997).[3] The poliheuristic theory, then, is compatible with a host of contingency theories of decision and judgment which credit the decision maker with enough flexibility to adapt his/her decision process to changing problem and environmental demands and to his/her own cognitive/individual traits (Abelson and Levi 1985; Beach and Mitchell 1978; Mintz et al. 1997; Payne, Bettman, and Johnson 1988, 1993; Tetlock 1992; Tetlock and Boettger 1989).

---

[2]Mintz and Geva (1997) distinguish between the *adoption* or *acceptance* of alternatives vs. the *rejection* of options.

[3]March and Olsen (1989) refer to the selection of decision rules in terms of anticipatory action vs. consequential action. We would argue that anticipatory action corresponds more closely to rational choice/expected utility notions of "[choosing] the alternative that has the best consequences" (ibid. 23) whereas obligatory action is more closely associated with cognitive approaches that emphasize "[doing] what is most appropriate" (ibid.).

The poliheuristic theory thus embodies fundamental elements of two disciplines concerned with decision making: cognitive psychology and political science (Hermann 1986, x-xi; see also Mintz et al. 1997). "From the former, the interesting questions center around how the decision maker(s) selects or rejects alternatives in light of time constraints, uncertainties, risks, task complexities, and so forth. From the latter come political issues, à la Lasswell, such as who wins and who loses politically as a consequence of the decision." (Mintz et al. 1997, p. 554).

The poliheuristic theory is based on five main processing characteristics of decision making: (1) nonholistic search, (2) dimension-based processing, (3) noncompensatory decision rules, (4) satisficing behavior, and (5) order-sensitive search (see Mintz and Geva 1997; Mintz et al. 1997). For the purposes of this project we concentrate on dimension-based processing, noncompensatory decision rules, and on maximizing versus satisficing behavior.

Dimension-Based Processing

Alternative vs. dimension-based strategies have been identified in the literature (see Ford et al. 1989; Payne, Bettman, and Johnson 1988, 1993) as two "pure" modes of information acquisition. A dimension can be represented in a number of different ways. It can be thought of as an organizing theme (OT) for related information as well as variables (Ostrom et al. 1980). In this sense, a political dimension that conveys the political implications of a chosen alternative could include variables such as public opinion polls, domestic opposition, the leader's popularity and other such factors related to this general organizing theme (see also Mintz and Geva 1997). A dimension can also be thought of as the thematic basis (or criterion) underlying the evaluation of an alternative. For example, the Secretary of Defense would be responsible for presenting evidence pertaining to the feasibility of any military operation (Geva, DeRouen, and Mintz 1993; Geva, Redd, and Mintz 2000; Mintz et al. 1997).[4]

Alternatives represent different courses of action such as "accept" and "reject." Alternative-based strategies imply a process whereby a decision maker sequentially reviews all items of information within a given alternative across dimensions and then proceeds in this manner for any subsequent alternatives. In contrast, a dimension-based strategy signifies that an individual focuses on a given dimension and then reviews information within that dimension across alternatives and then continues the process for another dimension (Payne 1976). Riggle and Johnson (1996) have suggested that these two modes of decision making symbolize two poles along an information-processing continuum (see also Mintz et al. 1997).

Identifying these two modes of processing information is important both because of what various decision theories have to say about which strategy a decision maker will utilize as well as what they suggest about a decision maker's attempts to deal with task complexities. Because expected utility speaks of maximizing product sums across alternative courses of action, it implies an alternative-based search on the part of decision makers. Changes from alternative to dimension-based strategies (or vice versa) can also be thought of in terms of reactions to cognitive complexity. Olshavsky (1979), Payne, Bettman, and Johnson (1988, 1993), and other scholars (e.g., Mintz et al. 1997) have shown that processing characteristics vary as a result of the choice environment. In other words, the strategy that a decision maker employs is very often contingent upon, among other things, the difficulty of the task being undertaken. Olshavsky (1979) notes that increasing task complexity leads to decision strategies that attempt to alleviate cognitive strain. Russo and Dosher (1983) specifically state that intradimensional, or dimension-based, processing is cognitively easier and hence more likely to be employed in cognitively demanding conditions. Therefore, strategy shifts from alternative-based to dimension-based procedures (or vice versa) can be "conceptualized as a movement between more complex, more demanding . . . reasoning (associated with the alternative-based strategy) and less complex, less demanding . . . rules (associated with a dimension-based strategy)" (Mintz et al. 1997, 554-

[4]This conceptualization is somewhat stylized and pure in nature; of course, it is quite possible—and surely probable—that advisers often represent or comment on more than one dimension. For example, it would be quite plausible to expect that the Chief of Staff (political adviser) might also offer advice pertaining to the economic or diplomatic ramifications of a given alternative.

55). The poliheuristic theory asserts that in situations where cognitive complexity is high or in any situation wherein leaders are faced with cognitive and/or environmental constraints, decision makers will use an attribute, or dimension-based process instead of an alternative-based approach for processing information.

Noncompensatory Strategies

In general, the compensatory principle refers to decision strategies that attempt to make trade-offs among attributes (Payne, Bettman, and Johnson 1993). High values on one attribute (dimension) can compensate for low values on another dimension (ibid.; see also Billings and Scherer 1988; Ford et al. 1989; Hogarth 1987; Payne, Bettman, and Johnson 1988). In contrast, the noncompensatory principle suggests, "a low score on one dimension cannot be compensated for by a high score on another dimension" (emphasis added) (Ford et al. 1989; see also Billings and Marcus 1983; Billings and Scherer 1988; Hogarth 1987; Payne, Bettman, and Johnson 1988, 1993). In other words, decision makers do not make trade-offs between high and low scores. Hogarth (1987, 77) states that, psychologically, trade-offs are difficult to make because decision makers find them difficult to execute as a result of "information-processing limitations."[5]

Both expected utility and cybernetic theories of decision making assume decision makers typically utilize compensatory decision rules. In contrast, cognitive approaches, including the poliheuristic theory of decision making, posit that decision makers employ noncompensatory rules of decision making. Mintz (1995, 337) states "Numerous experimental studies . . . [investigating] how decisions *are actually being made* reveal that seldom do decision makers employ holistic or compensatory processes during complex decisions" (emphasis in original) (see also Ford et al. 1989; Payne, Bettman, and Johnson 1988).

The noncompensatory principle of decision making has been examined in a number of different contexts as well as through the use of various methods. We present here a few of the more important contributions that have addressed the noncompensatory principle either in whole or in part.

The literature on the noncompensatory principle began as a concern with the cognitive and psychological processes of decision making in general. The noncompensatory principle was first discussed by scholars such as Einhorn (1970, 1971), Payne (1976), and Olshavsky (1979) who were concerned about how the complexity of decision tasks affected decision processes. Using various experimental methods (verbal protocols and information boards), these authors found that as task complexity increased, so did the use of noncompensatory strategies. Billings and Scherer (1988) used an information search board in an experiment between judgment and choice and found that choice situations led to more EBA (i.e., noncompensatory) strategies than did judgment situations. Ford et al. (1989, 75) summarized the literature in general that employed both verbal protocols and information board experimental methodologies and found "noncompensatory strategies were the dominant mode used by decision makers" (see also Payne, Bettman, and Johnson 1988). While these studies are important and paved the way for future research, they have been restricted to decision making in general, and have excluded the study of political decision making.

Mintz (1993), in his study of the Persian Gulf war, began the extension of the noncompensatory principle to the field of foreign policy decision making. Specifically, Mintz (ibid.) argued that the decision by the United States to attack Iraq followed the noncompensatory principle of elimination by aspects (EBA). Mintz (ibid., 598) specified the noncompensatory principle for use in foreign policy situations by arguing that the political dimension is the paramount attribute. Moreover, "in a choice situation, if a certain alternative is unacceptable on a given dimension (e.g., it is unacceptable politically), then a high score on another dimension (e.g., the military) *cannot* compensate/counteract for it, and hence the alternative is eliminated" (emphasis in original) (see also Mintz and Geva 1997). By examining historical documents and written accounts of the deliberations leading up to the conflict, Mintz (1993, 606-7) was able to show that the political dimension was the most salient in President Bush's decision calculus with the military/strategic dimension also playing a critical role. He further points out there was no comprehensive (i.e. search for compensatory trade-offs) evaluation of all

[5] See Baron and Spranca (1997), Ritov and Baron (1999), and Tetlock et al. (2000) for a discussion of taboo trade-offs and protected values, which correlate to the notions of compensatory and noncompensatory processing.

the alternatives and, in fact, it was quite obvious President Bush did not even consider the Do Nothing option (ibid., 607).

In several experimental studies, Mintz and Geva (1997), Mintz, Geva, and Redd (1995), Mintz et al. (1997), and Redd (2002) found, among other things, that decision makers tend to employ noncompensatory strategies en route to a foreign policy choice. Geva, Redd, and Mintz (2000, 34), also using experimental results, found evidence supporting the noncompensatory principle noting "the appearance of a negative political value early in the process was sufficient to eliminate that alternative from being chosen." Finally, Mintz (1995), using two Israeli case studies, showed that the noncompensatory principle could be applied to theories of coalition formation as well.

The strength of compensatory models of decision making lies in both the volume of work as well as in the diverse methodologies employed by proponents of these models. Both rational actor/expected utility (e.g., Bueno de Mesquita and Lalman 1990) and cybernetic models (e.g., James and Oneal 1991; Ostrom and Job 1986) often assume compensatory strategies. Furthermore, the combination of formal modeling, empirical analysis and generally correct predictions helps make these studies powerful tools in the study of foreign policy decision making. However, as Mintz (1995, 336) states, while these models have greater 'outcome validity' (making correct predictions), they are usually characterized as somewhat deficient in 'process validity' (describing what actually happens). In contrast, experimental and case study approaches of the noncompensatory principle of foreign policy decision making have had greater process validity, i.e., they actually get at the heart of *how* decisions are made and *how* information is processed.

Satisficing Strategies

The poliheuristic theory of decision making posits that decision makers 'satisfice' rather than 'maximize' utility (Mintz and Geva 1997; Mintz et al. 1997). Satisficing implies that decision makers stop searching for information once they have found a satisfactory alternative. They "seek a satisfactory solution rather than attempt to search every nook and cranny of the problem space. Even the expert chess player, for example, does not pursue each and every alternative possibility at each choice point, but simply examines a number of possibilities that satisfy him/her that s/he is making the correct, or at least best, move" (Sage 1990, 309). This satisfactory alternative need not be an optimal one, merely one that satisfies some *a priori* minimum threshold (Monroe 1991; Zey 1992).

The notion of satisficing was first introduced by Simon (1955, 1957) in his boundedly rational model of decision making. The basic argument is that individuals face constraints that limit their computational capabilities, their memories and recall abilities, etc. Because of these constraints, individuals develop decision procedures that enable them to deal more effectively and decisively with both their own cognitive limitations and with the demands imposed by the decision environment (March 1986; Simon 1957). Simon (1957) used the term 'satisficing' to denote these decision procedures.

Specifically, a satisficing strategy suggests a process whereby alternatives are considered one at a time, in the order they occur in the choice set (Payne, Bettman, and Johnson 1993). The decision maker compares alternatives to pre-determined values or thresholds along a selected set of dimensions instead of "evaluating each alternative on each dimension and comparing the sum expected utilities of all alternatives" (Mintz and Geva 1997, 87). Suedfeld and Tetlock (1992, 67) concur by stating that in the real world, "values, alternatives, probabilities, and outcomes are not as clear as is required for ideal decision making. The need to make many choices in a short period of time, the complexity of the interactions that determine outcomes, and the uncertainty surrounding probabilities, all compel human beings to make their choices by bounded rationality: a simplified model of the decision environment."

The difference then between maximizing and satisficing decision strategies is that in maximizing decision strategies, alternatives are compared to one another and the alternative with the highest utility—however that is defined—is chosen. In satsificing decision strategies, alternatives are compared to a threshold, and the first alternative to meet or surpass that threshold is selected. The poliheuristic theory stresses satisficing not only because it is concerned with finding "acceptable" alternatives instead of maximizing ones, but also because it is possible that not all dimensions or alternatives will be considered prior to a decision being made. In an experimental study, Redd (2004) finds evidence to support the proposition that decision makers satisfice, rather than maximize, utility under certain conditions.

PROCESS TRACING METHODS AND THE DECISION BOARD PLATFORM

Process tracing is a methodology designed to help identify and classify decision-making processes. Cognitive and social psychological theories are often used in studies of decision making but are not easily tested using traditional case studies alone. Moreover, it is not always possible to use standard empirical data sets because it is often not possible to explore the important questions and hypotheses using such data sets. In the late 1970s, George (1979) advocated process tracing, a method that, until that time, had not been rigorously applied in studies of foreign policy decision making. As Mintz et al. (1997, 556) state, "[Process tracing's] main strength is its ability to identify specific strategies used by decision makers and to test theoretically derived implications of situational and personal variables on the decision process and its outcome."

Process tracing directly identifies what information is being accessed to form a judgment and the order in which the information is accessed (Ford et al. 1989). This knowledge can then be used to make inferences about which decision strategies were employed en route to a choice. Larson (1985) and Khong (1992) used process-tracing techniques in studies of the origins of the containment doctrine and on decision making during the Vietnam War, respectively (see also Bennett and George 1997 for a more general discussion of process-tracing methods in case study research). Experimental process-tracing methods have thus far been most often used in studies of voter choice (see e.g., Johnson and Riggle 1994; Lau 1995; Lau and Redlawsk 1992; Riggle and Johnson 1996; Taber and Steenbergen 1995). Mintz and Geva (1997), Mintz et al. (1997), and Redd (2002, 2004) have used process-tracing techniques in studies of foreign policy decision making.

The Decision Board was developed by Dr. Alex Mintz to facilitate process tracing via a computerized system. As shown in Figure 1, the core structure of the Decision Board platform is a matrix of alternatives and dimensions on which the alternatives are evaluated (see Mintz et al. 1997). The computerized board records key features of the decision-making process. These features are subsequently used to identify decision strategies of policy makers.[6] A major feature that is recorded is the sequence in which the decision maker accesses the information. Version 4.0 of the Decision Board is available at www.decisionboard.org/academic.

[6]The Decision Board Simulator 4.0 has been used for research, teaching, and training. "It has been used in research to test theories of decision making (expected utility, prospect theory, cybernetic theory, poliheuristic theory); to assess the effect of framing and affect on decision making; for modeling voting games and electoral campaigns; for process tracing of political and economic trends and events; and to understand consumer behavior and choice. It has been used in teaching for courses in international relations, public policy and public administration, and management. The board has been used at 12 universities, including the University of Connecticut, the University of Michigan; National Defense University; University of Canterbury, New Zealand; China Foreign Affairs University in Beijing, China; School of Management at Tel Aviv University, Israel; the University of Wisconsin-Milwaukee; U.S. Air Force Academy; Yale University; and the Program in Foreign Policy Decision Making, and the Institute for Science, Technology and Public Policy in the George Bush School of Government and Public Service at Texas A&M University. Finally, the board has been used in training for emergency response decision making, bargaining, negotiation, mediation, and analysis of a variety of crisis situations." (www.decisionboard.org/academic/)

Figure 1. Decision Board Platform

Please remember to select at least one implication and one decision.

Decision Board	Border Crossing Sensors	Environmental Monitors	Local Emergency Responders	Do Nothing	Weight
Military Dimension	Select	Select	Select	Select	Add
Economic Dimension	Select	Select	Select	Select	Add
Political Dimension	Select	Select	Select	Select	Add
Final Choice:					

Final Decision

A decision problem "typically consists of the selection of an alternative from a set of available alternatives. The choice set is evaluated along single or, more typically, multiple dimensions. The 'values' in the matrix represent the evaluation of a given alternative on a given dimension. These information bins can be opened to reveal their contents by the click of a mouse, whereas decisions are made by clicking on the choice box of a desired alternative" (Mintz et al. 1997). The computerized Decision Board records (a) the sequence in which decision makers acquire the information, (b) the number of items that respondents view for every alternative along every dimension, and (c) the amount of time that elapses from the time respondents begin the task until they make their choice. Version 4.0 of the Decision Board also displays the "decision portraits" of decision makers and calculates holistic versus nonholistic search patterns and maximizing versus satisficing decision rules. Using process-tracing techniques, one can identify the strategy selection and decision model of leaders and other decision makers.

For this project, a policy scenario dealing with combating terrorism was used to introduce alternatives and dimensions into the Decision Board.[7] The scenario stated that the administration was faced with a decision about which technologies to pursue in fighting the war on terror. In this scenario, the decision maker was presented with four alternatives:

- Border Crossing Sensors
- Environmental Monitors
- Local Emergency Responders
- Do Nothing

The dimensions that were employed in the scenario represent decision criteria that were found to be relevant in other studies of foreign policy decisions in international relations (see James and Oneal 1991; Mintz and Geva 1997; Mintz et al. 1997; Morgan and Bickers 1992; Ostrom and Job 1986). Hence, the dimensions included in the Decision Board were as follows:

- Military
- Economic
- Political

Following the definition of the four alternatives and three dimensions, the values were inserted in the decision matrix. These values consisted of a descriptive statement and a summarizing numeric value (on a scale from -10 to +10).[8]

---

[7] The experimental task and the decision scenario are described in detail in Appendix A.

[8] The decision matrix is presented in its entirety in Appendix B.

METHODS

Subjects

Forty-six undergraduate students at the University of Wisconsin-Milwaukee (UWM) and fifty officers at National Defense University (NDU) participated in the initial experiment.[9] The undergraduate student subjects were randomly recruited from several political science courses. The officers were recruited from a leadership course taught over two semesters at NDU. Of the officers at NDU, 5 were Captains, 31 were Lt. Colonels, 13 were Colonels and 1 was a Brigadier General. These officers represented all four branches of the U.S. armed forces and several branches of the Reserve and National Guard. The study used the Decision Board platform (Version 4.0) as a "process tracer." The subjects were randomly assigned to one of four experimental conditions.

Design

A 2 X 2 between-groups factorial design was employed. The two factors were as follows: (1) Framing of likelihood of funding (emphasis on probability of being funded vs. emphasis on probability of not being funded), and (2) Certainty effects (certain vs. uncertain that technology will function as designed).

The Independent and Dependent Variables

The independent variables consisted of the framing of the likelihood of funding from Congress for the new antiterrorism technologies and the degree of certainty that the proposed antiterrorism technologies would work as designed as well as process-tracing parameters of decision making such as whether subjects used alternative-based or dimension-based strategies, and whether they employed compensatory or non-compensatory decision rules (*Information Acquisition Patterns*). The dependent variable in this study consisted of the *Choices* subjects made.[10]

The *Choices* subjects made were categorized as "correct" and "incorrect" choices. Multiplying the numerical rating of the alternative by the subject's rating of a given dimension yielded a weighted rating of the alternative along the given dimension. A cumulative "score" of the alternative was then calculated by summarizing all the weighted ratings of the alternative along each dimension. If the subject did, in fact, select the highest scoring alternative, we coded his/her choice as the "correct" one.

Measures of alternative vs. dimension-based processing were calculated using Billings and Scherer's (1988) search index. The index ranges from -1 (purely dimensional processing) to +1 (purely alternative-based processing). The scoring of subjects' moves was determined using Billings and Scherer's (ibid., 10) procedure (see Mintz et al. 1997). As in Billings and Scherer (ibid.), shifts were disregarded. The index tallies the number of dimensional moves (d), alternative moves (a), and shifts (s), and uses the equation $I = (a - d)/(a + d)$ to define the search index. Positive numbers indicate alternative-based moves, while negative numbers imply dimensional moves.

---

[9]Previous experimental/simulation research in international affairs also used students to test specific decision hypotheses (see Beer et al. 1987; Boettcher 1995). Zinnes (1966) replicated World War I decisions in a simulation study using high school students. Mintz, Geva, and Redd (1995), using the Foreign Policy Decision Board Platform, obtained similar results using both college students and Air Force commanders (see also Mintz et al. 1997). Of course, we are not asserting that students operating in an experimental setting equal the high level, real-world context of foreign policy decision making. Instead, we are arguing that experimental simulations of these actual, real-world foreign policy settings may provide insights into the ways in which uncertainty and framing can influence national security-level decision making. See Tetlock (1983) for a discussion of the strengths and weaknesses associated with experimental research in the social sciences.

[10]*Information Acquisition Patterns also* appear as dependent variables when testing for the influence of framing and uncertainty on decision strategies. They then become independent variables in order to test for the effects of decision strategies on choice.

The compensatory vs. noncompensatory measure comes from Astorino-Courtois (2000), and her measure is based on Payne, Bettman, and Johnson's (1993) discussion of consistency vs. selectivity in information processing (see also Redd 2002). Payne, Bettman, and Johnson (ibid., 30) state "more consistent processing across alternatives is indicative of a more compensatory decision strategy" (see also Payne 1976). The index for this particular decision matrix ranges from zero, representing complete consistency (compensatory processing), to twelve for the CSalt measure, and zero to eight for the CSdim measure, indicating maximum selectivity (noncompensatory processing). The Consistency/Selectivity by alternative measure is as follows:

$$CS_{alt} = \frac{1}{2} \sum \forall y \neq z \left| \sum_{n=1}^{n} a_{yn} - \sum_{n=1}^{n} a_{zn} \right|$$

where *n* is the number of alternatives in the choice set, and *a* represents the number of information bins accessed per alternative *y*, *z* and so on. The Consistency/Selectivity by dimension measure is as follows:

$$CS_{dim} = \frac{1}{2} \sum \forall u \neq w \left| \sum_{n=1}^{n} a_{um} - \sum_{n=1}^{n} a_{wm} \right|$$

where *m* is the number of dimensions in the choice set, and *a* is the number of information bins accessed per dimension *u*, *w* and so on.

An example (using the decision matrix below) demonstrates how the calculations of the Consistency-Selectivity measures were done.

Decision Matrix

	alternative 1	**alternative 2**	**alternative 3**	**alternative 4**
dimension A	1	2	3	
dimension B	8	10		
dimension C	9		4	6
dimension D			5	7
	3	2	3	2

CS_{alt} = ½ [|(3-2)| + |(3-3)| + |(3-2)| + |(2-3)| + |(2-3)| + |(2-2)| + |(3-3)| + |(3-2)| + |(3-2)| + |(2-3)| + |(2-2)| + |(2-3)|]

= ½ [1 + 0 + 1 + 1 + 1 + 0 + 0 + 1 + 1 + 1 + 0 + 1]

= ½ [8]

= 4

Examining the scores for alternative 1 we see in the example cited above that the decision maker began by accessing information at the nexus of dimension A and alternative 1, then proceeded within dimension A to alternative 2 and so forth. Overall, the decision maker accessed three information bins for alternative 1, across dimensions A, B and C. Two information bins were accessed for alternative 2, three for alternative 3, and two for alternative 4. The CS_{alt} measure yields a score of 4, signifying a fairly consistent search, implying the use of a compensatory strategy. In the matrix above, the CS_{dim} measure also leads to a score of 4, again indicating a consistent and compensatory search.[11] We also used the noncompensatory measure devised by Mintz and Geva (1997) to verify the Astorino-Courtois measure (2000).

The Research Instrument

A 4 X 3 (alternatives X dimensions) matrix was implemented. The version used for the experiment was developed as an online application. The Decision Board has several advantages: a user-friendly interface, multimedia capacity, and the ability to record the cognitive "moves" of decision makers. In this case, the Decision Board included twelve information bins, which contained information pertaining to the evaluation of a given alternative along a given dimension. The information was presented as an evaluative statement followed by a corresponding numerical evaluation. For example, "Using local emergency responders allows the military to correlate antiterrorism activities with local communities. This provides for a more 'comprehensive' antiterrorism shield for the United States. I would rate this alternative as 7." Decision makers could open any information bin by clicking on it. Subjects indicated their choices by clicking on a choice button underneath the corresponding alternative. Each subject dealt with only one of the four following conditions: positive framing-certain technology, positive framing-uncertain technology, negative framing-certain technology, and negative framing-uncertain technology.

Experimental Manipulations

In order to determine the influence of the importance of advisers and the order of their appearance in decision processes and to determine the influence of decision processes on choice, two factors were examined.

Manipulation of Framing

Subjects in the positive framing condition were told, "At the present time, because of the war on terrorism, there is approximately a 90% chance that Congress will fund at least one of these options. Congress has committed verbally and in writing to do whatever it takes to protect the American public from terrorism." In contrast, those in the negative framing condition were told, "At the present time, because of the recent war in Iraq, there is approximately a 10% chance that Congress will not fund any of these options. Congress may be constrained in its spending because of a weak domestic economy and the ongoing war in Iraq and the cost of the war approaching $100 billion."

Manipulation of Certainty

Subjects in the certain condition were told, "At this stage there is a high level of certainty that these future technologies will be successful and will work as conceived of and designed. Many in the scientific community are encouraged by the progress made so far and are hopeful that these options and the technology associated with them will actually work." In contrast, those in the uncertain condition were told, "At this stage there is a high level of uncertainty about whether these future technologies will be successful and will work as conceived of and designed. Many in the scientific community are skeptical about the progress made so far and doubt that these options and the technology associated with them will actually work."

Since many policy decisions are made under time and informational constraints, all of the subjects were subjected to time pressure in order to increase the "mundane reality" (Aronson and Carlsmith 1968). The experimental manipulation consisted of instructions indicating that there was a time constraint. However, the subjects were not actually restricted in the amount of time available.

---

[11] It is possible to end up with different scores for the CS_{alt} and CS_{dim} measures depending on the search pattern of the decision maker.

Procedure

Two samples were chosen to examine the decision making processing activity—real-world decision makers represented by officers participating in the leadership program at NDU and undergraduate student decision makers at a major state university. The students provide a comparison and control for the NDU sample. The undergraduate students were administered the online experiment in a computer lab at the University of Wisconsin-Milwaukee and the NDU attendees were tested online via the National Defense University. Each subject operated individually on a computer. The instructions and decision scenarios were displayed on the computer screen. Subjects were informed that they would be presented with a specific scenario concerning various technologies being developed to combat terrorism and with a decision matrix containing alternatives and the evaluations of those alternatives along three different dimensions: military, economic, and political. The subjects were instructed to make the best choice among the available options. Following the policy decision, a post-decision questionnaire was administered, followed by a detailed debriefing.

RESULTS

The data analysis focused on determining how the framing (the likelihood of funding antiterrorism measures from Congress) and the degree of certainty (the functionality of these antiterrorism measures) influenced strategy selection and choice, as well as how decision processes themselves affected choice. We first present significant results from the experiments with student subjects. These will form a baseline with which results from the more experienced NDU can be compared.

Framing, Certainty, Strategy Selection, and Choice

Before reporting the detailed results for the two types of subjects, it is important to note that the manipulations for framing and certainty affected choices in both subject populations. Using Analysis of Variance (ANOVA) methods, for the student subjects the framing manipulation was significant $F(1, 41) = 7.43$ $p < .009$, positive frame ($M = 8.00$), negative frame ($M = 6.27$) (ANOVA utilizes an F-test and "M" refers to the means for the corresponding conditions). The certainty manipulation for the student subjects was also significant $F(1, 41) = 10.19$ $p < .003$, certain ($M = 5.86$), uncertain ($M = 3.57$). For the military subjects, the framing manipulation was significant $F(1, 45) = 7.42$ $p < .009$, positive frame ($M = 8.12$), negative frame ($M = 6.50$). The certainty manipulation for the military subjects was also significant $F(1, 45) = 7.63$ $p < .008$, certain ($M = 6.56$), uncertain ($M = 4.75$). In other words, subjects responded to the manipulations imposed by the researchers, meaning that any significant results can be attributed to the researchers' manipulations of the independent variables.

University of Wisconsin-Milwaukee (UWM) Student Subjects

Using ANOVA methods and the Search Index (SI), we found a close to conventionally significant result $F(1, 42) = 3.44$ $p < .07$ for the certainty manipulation. When presented with certainty, subjects used more alternative-based procedures ($M = .415$) than when presented with uncertainty ($M = -.010$). In the uncertainty situation, subjects operated in a more dimension-based fashion. This suggests that when UWM student subjects were faced with the perhaps more cognitively demanding uncertain conditions they tended to resort to dimension-based strategies, which have been shown to help alleviate cognitive strain (Russo and Dosher 1983).

We also tested for the influence of certainty and framing on participants' likelihood of making the "correct" choice. As stated earlier, multiplying the numerical rating of the alternative by the subject's rating of a given dimension identified the "correct" choice. Each alternative then had a cumulative "score," and we subsequently coded whether the subject did, in fact, select the highest scoring alternative. Using the z test for proportions (Langer and Abelson 1972) we found a main effect for certainty ($z = 2.67$ $p < .005$). Table 1 shows that when student subjects were faced with certain technology, they made the "correct" choice only

20% of the time, but when they were faced with uncertainty, they made the correct choice 57% of the time. Our explanation for this finding is that the students had a preference over preference (a priori bias toward the selection of a particular alternative) to Do Nothing in this case, so the certainty/uncertainty manipulation did not influence their choices in a meaningful way.

Table 1. Effect of Certainty on Choice (University of Wisconsin-Milwaukee Student Subjects)

Certainty	
Certainty	**Uncertainty**
20%	57%

We also used a different definition for "correct" choice, simply labeling the Do Nothing alternative as the "best" choice because it had the highest cumulative score. Again using the z test for proportions we found significant results for the effect of framing and the use of maximizing versus satisficing strategies on correct choice. We found a main effect for framing ($z = 1.82$ $p < .05$), with Table 2 showing that 54% of those exposed to a positive frame made the "best" choice while only 30% of those exposed to a negative frame did so. This result is somewhat counterintuitive since in the positive frame the three antiterrorism technologies were framed positively, i.e., Congress would fund them. Again, the students' preference over preference led them to choose the Do Nothing (correct choice) option even though the other options were framed positively.

Table 2. Effect of Framing on Choice as a Function of Maximizing vs. Satisficing Strategies (University of Wisconsin-Milwaukee Student Subjects)

Framing	
Positive	**Negative**
54%	30%

We also found a significant effect for the certainty manipulation on subjects' propensity to maximize versus satisfice. Using a chi-square test ($\chi^2 = 5.84$ $p < .02$) we found that participants faced with certain technology used a maximizing strategy only 22% of the time, while those faced with uncertainty maximized 57% of the time (see Table 3). In other words, student subjects responded to the uncertainty of the antiterrorism technology by maximizing their search for information.

Table 3. Effect of Certainty on Decision Strategy (University of Wisconsin-Milwaukee Student Subjects)

Maximizing Decision Strategy	
Certainty	**Uncertainty**
22%	57%

Several significant results were generated by examining the influence of the two manipulated independent variables on participants' use of compensatory versus noncompensatory strategies.[12] Using the z test for proportions we found a significant main effect for framing and noncompensatory processing (see Tables 4-6). Specifically, we found two main effects and an interaction effect. In the main effect for framing ($z = 3.05$ $p < .003$), 46% of the subjects faced with a positive frame chose the "correct" option whereas only 15% of those faced with a negative frame did so. The main effect for decision strategy ($z = 1.66$ $p < .05$) shows that 36% of those subjects employing a compensatory strategy were able to make the correct choice while only 25% of those using a noncompensatory strategy were able to do so. The interaction effect ($z = 2.27$ $p < .02$) shows that no one faced with a negative frame and using noncompensatory strategies was able to make the correct choice. Again, these findings show that even though the three antiterrorism technologies were framed positively and subjects used compensatory strategies, students' preferences led them to choose the Do Nothing option.

Table 4. Effect of Framing on Choice in the Context of Noncompensatory vs. Compensatory Processing (University of Wisconsin-Milwaukee Student Subjects)

Framing	
Positive	**Negative**
46%	15%

Table 5. Effect of Decision Strategy on Choice in the Context of Framing (University of Wisconsin-Milwaukee Student Subjects)

Decision Strategy	
Compensatory	**Noncompensatory**
36%	25%

Table 6. Effect of Framing and Decision Strategy on Choice (University of Wisconsin-Milwaukee Student Subjects)

	Framing	
Decision Strategy	**Positive**	**Negative**
Compensatory	41%	30%
Noncompensatory	50%	0%

[12] We present results only for the CSdim measure.

We also found two significant results for certainty and noncompensatory strategies (see Tables 7 and 8). We found a main effect for certainty ($z = 2.71$ $p < .005$) wherein only 14% of those faced with certainty were able to make the correct choice while 39% faced with uncertainty were able to do so. The main effect for decision strategy ($z = 2.27$ $p < .02$) shows that 36% of those subjects using compensatory strategies were able to make the correct choice while only 17% using noncompensatory strategies were able to do so. These results are similar to those reported in Tables 3 and 5.

Table 7. Effect of Certainty on Choice in the Context of Noncompensatory vs. Compensatory (University of Wisconsin-Milwaukee Student Subjects)

Certainty	
Certainty	**Uncertainty**
14%	39%

Table 8. Effect of Decision Strategy on Choice in the Context of Certainty (University of Wisconsin-Milwaukee Student Subjects)

Decision Strategy	
Compensatory	**Noncompensatory**
36%	17%

National Defense University (NDU) Military Subjects

Generally speaking, results from the military subjects stand in contrast to those from the less experienced undergraduate subjects. Using ANOVA methods and the Search Index (SI), we found a significant result $F(1, 46) = 6.56$ $p < .01$ for the certainty manipulation. However, the results were in the opposite direction from those of the student subjects. When presented with certainty, NDU subjects used more dimension-based procedures ($M = -.165$) than when presented with uncertainty ($M = .418$). Under conditions of uncertainty they operated in a more alternative-based fashion. It seems that when facing uncertainty with respect to the operation of the antiterrorism technologies, the military subjects decided to gather more information about these technologies by processing information about each alternative in an alternative-based fashion. When told the technologies were certain to succeed, subjects judged them on political, economic, and military merits.

Using the z test for proportions we also found a significant interaction effect between framing and the decision strategy used, i.e., alternative versus dimension-based procedures, and subjects making the "correct" choice (defined as the Do Nothing option) ($z = 2.48$ $p < .01$). Subjects facing a negative frame and using alternative-based procedures and a positive frame and dimension-based procedures were unable to make the correct choice (see Table 9). The total percentages are quite low here because very few of the military subjects chose the Do Nothing option. We also found a main effect for certainty and correct choice ($z = 2.58$ $p < .005$). Specifically, subjects faced with certainty were unable to make the correct choice (0%) while those faced with uncertainty made the correct choice 14% of the time (see Table 10). This finding is in line with previous effects of certainty on choice for student subjects.

Table 9. Effect of Framing and Decision Strategy on Choice (National Defense University Military Subjects)

	Framing	
Decision Strategy	**Positive**	**Negative**
Alternative-based	10%	0%
Dimension-based	0%	14%

Table 10. Effect of Certainty on Choice in the Context of Alternative vs. Dimension-Based Strategies (National Defense University Military Subjects)

Certainty	
Certainty	**Uncertainty**
0%	14%

Defining "correct" choice as multiplying the numerical rating of the alternative by the subject's own rating of a given dimension, we found several other significant relationships between the manipulated independent variables and choice as a function of decision strategy. We found a main effect for framing ($z = 2.97$ $p < .003$) wherein those faced with a positive frame, regardless of compensatory or noncompensatory processing, made the correct choice 38% of the time while those in the negative frame only did so 11% of the time (see Table 11). These findings are similar to those reported with student subjects and demonstrated in Table 4. We also found an interaction effect between decision strategy and framing ($z = 2.56$ $p < .01$) wherein those faced with a negative frame and using noncompensatory strategies were not able to choose correctly (0%) (see Table 12). These findings are in line with those reported in Table 6 for the student subjects; although, the dependent variable was defined slightly differently.

Table 11. Effect of Framing on Choice in the Context of Noncompensatory vs. Compensatory Processing (National Defense University Military Subjects)

Framing	
Positive	**Negative**
38%	11%

Table 12. Effect of Framing and Decision Strategy on Choice (National Defense University Military Subjects)

	Framing	
Decision Strategy	**Positive**	**Negative**
Compensatory	26%	21%
Noncompensatory	50%	0%

Using the same definition of correct choice we also found a relationship between certainty, decision strategy and choice. We found a main effect for certainty ($z = 2.56$ $p < .01$) wherein those faced with certain technology made the correct choice 36% of the time while those faced with uncertainty did so only 13% of the time (see Table 13). We also found an interaction effect between decision strategy and certainty ($z = 2.97$ $p < .003$) wherein those faced with uncertainty and using noncompensatory strategies did not choose correctly (0%) (see Table 14). In both cases, military subjects were more likely than UWM students to make the correct choice when faced with certainty. Again, this may be a function of the military subjects having a preference over preference for "doing something," i.e., choosing any option but the Do Nothing alternative.

Table 13. Effect of Certainty on Choice in the Context of Noncompensatory vs. Compensatory Processing (National Defense University Military Subjects)

Certainty	
Certainty	**Uncertainty**
36%	13%

Table 14. Effect of Certainty and Decision Strategy on Choice (National Defense University Military Subjects)

	Certainty	
Decision Strategy	**Certainty**	**Uncertainty**
Compensatory	21%	26%
Noncompensatory	50%	0%

UWM Student-NDU Military Subject Comparison

We compared student subject responses with NDU subject responses and generated the following results. First we compared student subjects' and NDU subjects' decisions to choose the Do Nothing response versus choosing one of the other options. Using a difference of proportions test for two different subject pools (z test) we found a significant difference between the two subject pools ($z = 3.13$ $p < .001$). A full 34% of the student subjects chose the Do Nothing option while 66% chose one of the other three alternatives, whereas only 8% of the NDU subjects chose the Do Nothing option and 92% chose one of the other options (see Table 15). This is a very interesting finding. If we consider the military subjects to be more experienced in what is essentially a budgeting decision, then we would naturally expect them to choose one of the three antiterrorism technologies knowing that it is better to opt for something than to do nothing. Conversely, student subjects, operating in more of a policy void, would be more likely to favor doing nothing over any other alternative.

Research Supported by the National Defense University, Contract No. DABJ29-03-P-0084
Institute for Science, Technology and Public Policy, George Bush School of Government and Public Service
Texas A&M University

Table 15. Differences Between University of UWM Student Subjects and NDU Military Subjects Choosing *Do Nothing* vs. *Do Something* Decision Strategies

	Choice	
Subject Group	**Do Nothing**	**Do Something**
UWM Student Subjects	34%	66%
NDU Military Subjects	8%	92%

We also compared the differences in choices of decision strategies using the same method. We found a significant difference between the two groups in their use of maximizing versus satisficing strategies in the two groups ($z = 2.39$ $p < .01$). We found that 40% of the student subjects chose a maximizing strategy while 60% chose a satisficing strategy. In contrast, only 18% of the NDU subjects chose a maximizing strategy and 82% chose to satisfice (see Table 16). It would appear that greater experience and familiarity with the general problem area encourages a more realistic, compromise position among the military subjects. Since military subjects are more likely to be familiar with issues related to antiterrorism in particular and have more experience generally in making decisions, they would tend to satisfice, i.e., make the choice that is "good enough" rather than maximizing, i.e., attempting to make the "best" decision.

Table 16. Differences Between University of UWM Student Subjects and NDU Military Subjects Choosing *Maximizing* vs. *Satisficing* Decision Strategies

	Decision Strategy	
Subject Group	**Maximizing**	**Satisficing**
UWM Student Subjects	40%	60%
NDU Military Subjects	18%	82%

We also found a significant difference between the UWM students and NDU officers in their choices of compensatory versus noncompensatory processing by alternative ($z = 2.36$ $p < .01$). Only 15% of the student subjects chose a noncompensatory strategy (85% chose a compensatory strategy) while 36% of the NDU military subjects chose a noncompensatory strategy (64% selected a compensatory strategy) (see Table 17). Once again, this would imply that NDU officers resorted to the use of cognitive shortcuts to a greater degree than did their student counterparts. This is further evidence of more experienced decision makers who tend to resort to strategies that alleviate cognitive strain.

Table 17. Differences Between University of UWM Student Subjects and NDU Military Subjects Choosing *Compensatory* vs. *Noncompensatory* Decision Strategies

	Decision Strategy	
Subject Group	**Compensatory**	**Noncompensatory**
UWM Student Subjects	85%	15%
NDU Military Subjects	64%	36%

We also analyzed differences between the two groups in the number of information bins accessed. The two groups differed in the overall number of cells accessed $F(1, 94) = 14.55$ $p < .0002$. The UWM students accessed more cells (M = 11.30) compared to their NDU military counterparts (M = 9.04). There were also significant differences as a function of condition. Under the condition of positive framing, the difference was significant $F(1, 47) = 6.82$ $p < .01$, where the UWM students again accessed more information (M = 11.33) compared to the military subjects (M = 9.24). Under negative framing $F(1, 45) = 7.39$ $p < .009$, UWM students opened more information bins (M = 11.27) than NDU military subjects (M = 8.84). Similar results were obtained for the certainty $F(1, 47) = 9.88$ $p < .003$, UWM subjects (M = 11.57), NDU subjects (M = 9.12) and uncertainty $F(1, 45) = 5.20$ $p < .03$, UWM subjects (M = 11.04), NDU subjects (M = 8.96) conditions. Again, the more experienced military decision makers needed less information before making a choice and these results held overall as well as for the different conditions of framing and certainty.

We also compared the choices of the two groups for the four different options. Using a chi-square test we found significant differences between the two groups ($\chi^2 = 12.11$ $p < .01$). Specifically, we found that military subjects were more likely to select the Border Crossing Sensors alternative while student subjects were more likely to choose the Do Nothing option (see Table 18). As we reported above, military subjects favored doing something as opposed to doing nothing.

Table 18. Differences Between University of UWM Student Subjects and NDU Military Subjects Choosing *Among Four Options*

	Choice			
Subject Group	**Border Crossing Sensors**	**Environmental Monitors**	**Local Emergency Responders**	**Do Nothing**
UWM Student Subjects	15 (34%)	3 (7%)	12 (26%)	16 (35%)
NDU Military Subjects	30 (58%)	3 (6%)	13 (26%)	4 (9%)

CONCLUSIONS

We analyzed how uncertainty and the framing of options affects decision makers' responses and choices with respect to policy options dealing with anti-terrorism technologies. We did so in an experimental setting using an online version of the Decision Board Platform with two different subject populations: student subjects and military commanders.

Our results show that uncertainty affects decision makers' selection of decision strategies. However, uncertainty affected our two subject pools in opposite ways: student subjects responded to uncertainty with more dimension-based processing while the military commanders employed alternative-based procedures when faced with uncertainty. The student subjects also tended to use maximizing strategies more often than did their military counterparts, who tended to satisfice. In contrast to the NDU subjects, UWM student subjects also tended to access more information en route to their choices.

Uncertainty also affected subjects' choices. Interestingly, uncertainty generally led to higher proportions of subjects making the "correct" decision in both subject pools. (Following decision theory conventions, a "correct" choice was defined as the choice alternative with the highest cumulative ratings by the subject along each dimension.) The major exception occurred for the military subjects when they were also employing noncompensatory strategies. Noncompensatory strategies are those that do not recognize trade-offs, or acceptable alternatives to a preferred attribute. When noncompensatory strategies were used, certainty aided the military subjects in choosing "correctly." Framing affected choice as well. In general, positive framing led to a greater likelihood of participants making the correct choice.

There were also marked differences in the two subject pools in processing information and in making choices. As mentioned above, many students tended to maximize (or search alternatives until the optimal one is found) while military commanders tended to satisfice (or search until an alternative that satisfies some minimal threshold is found). Also, students gathered more information than their military counterparts en route to choice. Military commanders were very reluctant to choose the Do Nothing option (8%), while student subjects were much more likely to do so (34%). The military commanders overwhelmingly favored the Border Crossing Sensors option while the student subjects were more evenly split between Border Crossing Sensors and the Do Nothing options.

Our research findings convey some important messages and applied lessons about how uncertainty and framing of scientific and technological information may influence decision processes and outcomes. The first, and perhaps the most important, lesson we learned from this study is that in real decision situations, uncertainty about technological innovations is not necessarily undesirable as officers tended to seek more information about the technologies when faced with uncertain choices. Uncertainty is a common characteristic of real decision making processes, and all complex science and technological issues involve some degree of uncertainty. Our study shows that greater uncertainty about new anti-terrorism technologies generally leads to a greater likelihood of subjects making the “correct” decision in both subject pools. The general implication of the findings on the effects of uncertainty is that, in the case of experienced decision makers, when more information is thought to be essential for making good decisions, learning tools that stress the uncertainty of the issue and allow for the access of more information are more likely to lead to the use of alternative-based information search strategies and the accessing of more information before decisions are made.

When constructing decision tools, two things should be kept in mind: (1) for policy decision makers, it is important to keep in mind that the uncertainty problem lies at the very heart of all complex science and technology issues. It is helpful to seek skeptical perspectives and alternative courses of action when facing such a complex decision situation; (2) it is the duty of policy analysts, experts, and advisors to inform decision makers of both certainties and the limits of knowledge, the positive and negative consequences as well as the strengths and weaknesses of each option. Even if the certainty about a technological innovation is high, being aware and cautious about the complexity and uncertain aspects of the new technology may contribute to quality decision choices.

The second important lesson learned here is that different framing of the same decision problem do affect decision process and choice outcomes, even for seasoned decision makers. This finding is consistent with previous experimental studies on framing effects (e.g. Tversky and Kahneman, 1981). The ways decision problems are framed are not always thought through carefully. Administrators, experts and advisors should be aware that the same decisional situation can be framed in different ways and that the different frames of the same decision problems can lead to different choices. Special training and experimentation with multiple frames and deep analysis on possible choice outcomes may make decision makers more aware of the general tendency to be influenced by the way information is presented. Training on frames should help trainees understand how various framing formats operate on decision making , help them avoid frame traps, mater framing and reframing techniques, and enhance multiple-frame management skills.

The third important lesson learned is that regardless of certainty or uncertainty and positive vs. negative framing, experienced decision makers, such as the military officers at National Defense University, are more likely to choose “doing something” even when “doing nothing” is an option and, in fact, even when “doing nothing” is the highest rated option. The NDU group was significantly more likely than the UWM group to choose this option (66% of UWM subjects and 92% of NDU subjects preferred to “do something.”). This finding may have been a function of the fact that the decision set before the subjects was basically a budgeting decision, and experienced decision makers “never leave money on the table.” It may also have been a function of the belief that in the war on terrorism, it is better to pursue some solution than to put off making a decision for the foreseeable future. The preference over preference (in this case for action over inaction) tendency may also be a function of NDU subjects’ military experience and training backgrounds. Compared to non-military subjects (i.e. UWM students), military officers have more training and experience in taking action and making quick decisions. "Doing nothing" may seem like a less acceptable option, even if it is presented in the choice set and in fact rated as the highest desirable option. Whatever the source of this tendency, military programs may need to pay more attention to this action orientation and minimize risk of only making action-based choices when sometimes, "doing nothing" is actually the best option.

The fourth significant lesson is about decision theory itself. Previously, rational choice theory –the expected utility model for example – has generally dominated decision making analysis and been widely used in various education and training programs in the fields of risk management, conflict resolution, leadership, foreign policy analysis, strategic planning, and political decision making. Our study shows that as an emerging theoretical framework – the poliheuristic decision theory - may represent a viable alternative theoretical framework to the existing decision models. The poliheuristic theory embodies fundamental elements of both rational and cognitive decision models and incorporates the conditions surrounding policy decisions, as well as the rational and cognitive processing characteristics associated with these surroundings. As shown in our study, real-world decision processes and outcomes appear to be more compatible with the poliheuristic propositions and explanations than with those derived from a strict rational choice model. As a more realistic decision model, the poliheuristic theory of decision making should be considered for designing future courses, projects and training programs.

The last lesson that can be summarized here is the potential of the Decision Board as a training and support tool for decision making on complex choice situations involving uncertainty, limited information and potential framing effects. The core structure of the Decision Board is a matrix of alternative and evaluation dimensions which reflect that fundamental construct of all decision problems. The computerized Decision Board has several advantages. First, it can be used to configure an unstructured, complicated decision problem into a relatively well-organized and cognitively manageable decision matrix. Second, it can be used to facilitate the process of identifying critical information, available options, and major attribute dimensions. Third, with the assistance of process-tracing techniques, it can be used to record the sequence in which decision makers acquire relevant information and the amount of time that elapses from the time respondents begin the task until they make their final choice. Finally, because the Decision Board is a computerized process-tracing program it allows varying experimental designs and manipulations to identify the influence of certain variables such as uncertainty and framing, on the processing characteristics, decision strategies and choice outcomes.

Future work should further explore the important issues we examined in this study. Replication of these experiments should shed more light on the validity of the results and garner additional information on the ways in which experienced decision makers reach their conclusions. This study indicated that uncertainty encourages more thorough information searches among experienced decision makers, and this is a finding that warrants further exploration. For example, thresholds of uncertainty may alter this relationship as may a number of other factors such as familiarity and immediacy. The finding that experienced decision makers are influenced by even the relatively straightforward framing used in this study also warrants further exploration and suggests additional training on frames may be called for. Other important factors such as accountability, ambiguity, familiarity, and information availability are but a few of the possible independent variables that can be examined in the context of decision making in the war on terror and other issues. With specific reference to antiterrorism technology, work can also be done to examine the public's reaction to the possible deployment and use of these antiterrorism technologies under the condition of uncertainty and framing differences.

Abelson, Robert P., and Ariel Levi. 1985. "Decision Making and Decision Theory." In *The Handbook of Social Psychology*, 3d ed., ed. Gardner Lindzey and Elliot Aronson. New York: Random House.

Anderson, Paul A. 1983. "Decision Making by Objection and the Cuban Missile Crisis." *Administrative Science Quarterly* 28: 201-22.

Aronson, Elliot, and J. Merrill Carlsmith. 1968. "Experimentation and Social Psychology." In *The Handbook of Social Psychology*, ed. Gardner Lindzey and Elliot Aronson. Reading, MA: Addison-Wesley.

Astorino-Courtois, Allison. 2000. "The Effects of Stakes and Threat on Foreign Policy Decision-Making." *Political Psychology* 21:489-510.

Baron, Jonathan, and Mark Spranca. 1997. "Protected Values." *Organizational Behavior and Human Decision Processes* 70:1-16.

Beach, Lee Roy, and Terence R. Mitchell. 1978. "A Contingency Model for the Selection of Decision Strategies." *Academy of Management Review* 3: 439-49.

Beer, Francis A., Alice F. Healy, Grant P. Sinclair, and Lyle E. Bourne, Jr. 1987. "War Cues and Foreign Policy Acts." *American Political Science Review* 81:701-15.

Bennett, Andrew, and Alexander L. George. 1997. Process tracing in case study research. Paper presented at the MacArthur Foundation Workshop on Case Study Methods, Belfer Center for Science and International Affairs (BCSIA), Harvard University, October 17-19.

Billings, Robert S., and Lisa L. Scherer. 1988. "The Effects of Response Mode and Importance on Decision-Making Strategies: Judgment Versus Choice." *Organizational Behavior and Human Decision Processes* 41:1-19.

Billings, Robert S., and Stephen A. Marcus. 1983. "Measures of Compensatory and Noncompensatory Models of Decision Behavior: Process Tracing Versus Policy Capturing." *Organizational Behavior and Human Performance* 31:331-52.

Boettcher, William A., III. 1995. "Context, Methods, Numbers, and Words: Prospect Theory in International Relations." *Journal of Conflict Resolution* 39:561-83.

Braunstein, Myron L. 1976. *Depth Perception Through Motion*. New York: Academic Press.

Bueno de Mesquita, Bruce, and David Lalman. 1990. "Domestic Opposition and Foreign War." *American Political Science Review* 84:747-65.

Campbell, M. B., and E. J. Heilweil. 2003. "Non-invasive Detection of Weapons of Mass Destruction Using THz Radiation." In *Terahertz for Military and Security Applications*, eds. R. Jennifer Hwu and Dwight Woolard. Bellingham, WA: Society of Photo-optical Instrumentation Engineers.

Castellan, John N., Jr., ed. 1993. *Individual and Group Decision Making: Current Issues*. Hillsdale, NJ: Lawrence Erlbaum.

DeRouen, Karl R., Jr. 1994. "The Decision Not to Use Force: A Noncompensatory Perspective." Discussion paper #21. The Program in Foreign Policy Decision Making, Texas A&M University.

DeRouen, Karl R., Jr. 2001. *Politics, Economics, and Presidential Use of Force Decision Making*. Lewiston, NY: The Edwin Mellen Press.

Einhorn, Hillel J. 1970. "The Use of Nonlinear, Noncompensatory Models in Decision Making." *Psychological Bulletin* 73:211-30.

Einhorn, Hillel J. 1971. "Use of Nonlinear, Noncompensatory Models as a Function of Task and Amount of Information." *Organizational Behavior and Human Performance* 6:1-27.

Feldman, Stanley. 1995. "Answering Survey Questions: The Measurement and Meaning of Public Opinion." In *Political Judgment: Structure and Process*, ed. Milton Lodge and Kathleen M. McGraw. Ann Arbor: University of Michigan Press.

Ford, J. Kevin, Neal Schmitt, Susan L. Schechtman, Brian M. Hults, and Mary L. Doherty. 1989. "Process Tracing Methods: Contributions, Problems, and Neglected Research Questions." *Organizational Behavior and Human Decision Processes* 43: 75-117.

Frisch, Deborah. 1993. "Reasons for Framing Effects." *Organizational Behavior and Human Decision Processes* 54: 399-429.

George, Alexander L. 1979. "The Causal Nexus between Cognitive Beliefs and Decision-Making Behavior: The 'Operational Code' Belief System." In *Psychological Models in International Politics*, ed. Lawrence S. Falkowski. Boulder, CO: Westview Press.

Geva, Nehemia, Karl R. DeRouen, Jr., and Alex Mintz. 1993. "The Political Incentive Explanation of Democratic Peace: Evidence from Experimental Research." *International Interactions* 18:215-29.

Geva, Nehemia, Steven B. Redd, and Alex Mintz. 2000. "Evolving vs. Static Decision Dimensions and Decision Processes: An Experimental Assessment of Poliheuristic Propositions." Mimeo. Texas A&M University.

Hermann, Margaret G. 1986. *Political Psychology*. San Francisco: Jossey-Bass.

Hogarth, Robin M. 1987. *Judgment and Choice: The Psychology of Decision*. 2d ed. New York, NY: John Wiley and Sons.

Hogarth, Robin M., ed. 1990. *Insights in Decision Making: A Tribute to Hillel J. Einhorn*. Chicago, IL: University of Chicago Press.

James, Patrick, and John R. Oneal. 1991. "The Influence of Domestic and International Politics on the President's Use of Force." *Journal of Conflict Resolution* 35: 307-32.

Jervis, Robert. 1976. *Perception and Misperception in International Politics*. Princeton, NJ: Princeton University Press.

Jervis, Robert. 1988. "War and Misperception." *Journal of Interdisciplinary History* 18:675-700.

Jervis, Robert. 1992. "Political Implications of Loss Aversion." *Political Psychology* 13:187-204.

Johnson, Mitzi M. S., and Ellen D. B. Riggle. 1994. "Age-Related Differences in Processing Information for Attitude-Laden Decisions." Presented at the Cognitive Aging Conference, Atlanta, Georgia.

Juslin, Peter, and Henry Montgomery, ed. 1999. *Judgment and Decision Making: Neo-Brunswikian and Process-Tracing Approaches*. Mahwah, NJ: Lawrence Erlbaum.

Kahneman, Daniel, and Amos Tversky. 1979. "Prospect Theory: An Analysis of Decision Under Risk." *Econometrica* 47: 263-91.

Khong, Yuen Foong. 1992. *Analogies at War: Korea, Munich, Dien Bien Phu, and the Vietnam Decisions of 1965*. Princeton, NJ: Princeton University Press.

Langer, Ellen J., and Robert P. Abelson. 1972. "The Semantics of Asking a Favor: How to Succeed in Getting Help without Really Dying." *Journal of Personality and Social Psychology* 24:26-32.

Larson, Deborah Welch. 1985. *Origins of Containment: A Psychological Explanation*. Princeton, NJ: Princeton University Press.

Lau, Richard R. 1995. "Information Search During an Election Campaign: Introducing a Processing-Tracing Methodology for Political Scientists. In *Political Judgment*, eds. Milton Lodge and Kathleen M. McGraw. Ann Arbor, MI: University of Michigan Press.

Lau, Richard R., and David P. Redlawsk. 1992. "How Voters Decide: A Process Tracing Study of Decision Making during Political Campaigns." Presented at the annual meeting of the American Political Science Association, Chicago, Illinois.

Levy, Jack S. 1992a. "An Introduction to Prospect Theory." *Political Psychology* 13: 171-86.

Levy, Jack S. 1992b. "Prospect Theory and International Relations: Theoretical Applications and Analytical Problems." *Political Psychology* 13: 283-310.

Maoz, Zeev. 1986. "Multiple Paths to Choice: An Approach for the Analysis of Foreign Policy Decision Making." In *Different Text Analysis Procedures for the Study of Decision Making*, eds. Irmtraud N. Gallhofer, Willem E. Saris, and Marianne Melman. Amsterdam. Sociometric Research Foundation.

Maoz, Zeev. 1997. "Decisional Stress, Individual Choice, and Policy Outcomes: The Arab-Israeli Conflict." In *Decisionmaking on War and Peace: The Cognitive-Rational Debate*, eds. Nehemia Geva and Alex Mintz. Boulder, CO: Lynne Rienner.

March, James G. 1986. "Bounded Rationality, Ambiguity, and the Engineering of Choice." In *Rational Choice*, ed. Jon Elster. New York, NY: New York University Press.

March, James G., and Johan P. Olsen. 1989. *Rediscovering Institutions: The Organizational Basis of Politics*. New York: Free Press.

Mintz, Alex. 1993. "The Decision to Attack Iraq: A Noncompensatory Theory of Decision Making." *Journal of Conflict Resolution* 37: 595-618.

Mintz, Alex. 1995. "The 'Noncompensatory Principle' of Coalition Formation." *Journal of Theoretical Politics* 7:335-49.

Mintz, Alex, and Nehemia Geva. 1997. "The Poliheuristic Theory of Foreign Policy Decision Making." In *Decisionmaking on War and Peace: The Cognitive-Rational Debate*, eds. Nehemia Geva and Alex Mintz. Boulder, CO: Lynne Rienner.

Mintz, Alex, Nehemia Geva, and Steven B. Redd. 1995. "The Impact of Dynamic and Static Choice Sets on Decision Strategy: An Analysis Utilizing the Decision Board Platform." Paper presented at the annual meeting of the International Studies Association, Chicago, Illinois, February 22-25.

Mintz, Alex, Nehemia Geva, Steven B. Redd, and Amy Carnes. 1997. "The Effect of Dynamic and Static Choice Sets on Political Decision Making: An Analysis Using the Decision Board Platform." *American Political Science Review* 91: 553-66.

Monroe, Kristen R. 1991. "The Theory of Rational Action: What is it? How Useful is it for Political Science? In *The Theory and Practice of Political Science*, ed. William J. Crotty. Evanston, IL: Northwestern University Press.

Morgan, T. Clifton, and Kenneth N. Bickers. 1992. "Domestic Discontent and the External Use of Force." *Journal of Conflict Resolution* 36: 25-52.

Olshavsky, Richard W. 1979. "Task Complexity and Contingent Processing in Decision Making: A Replication and Extension." *Organizational Behavior and Human Performance* 24:300-316.

Ostrom, Charles W., Jr., and Brian L. Job. 1986. "The President and the Political Use of Force." *American Political Science Review* 80: 541-66.

Ostrom, Thomas M., John H. Lingle, John B. Pryor, and Nehemia Geva. 1980. "Cognitive Organization of Person Impressions." In *Person Memory: The Cognitive Basis of Social Perception*, eds. Reid Hastie, Thomas M. Ostrom, Ebbe B. Ebbesen, Robert S. Wyer, Jr., David L. Hamilton, and Donal E. Carlston. Hillsdale, NJ: Lawrence Erlbaum.

Payne, John W. 1976. "Task Complexity and Contingent Processing in Decision Making: An Information Search and Protocol Analysis." *Organizational Behavior and Human Performance* 16:366-87.

Payne, John W., James R. Bettman, and Eric J. Johnson. 1988. "Adaptive Strategy Selection in Decision Making." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 14: 534-52.

Payne, John W., James R. Bettman, and Eric J. Johnson. 1993. *The Adaptive Decision Maker*. Cambridge: Cambridge University Press.

Redd, Steven B. 2002. "The Influence of Advisers on Foreign Policy Decision Making." *Journal of Conflict Resolution* 46: 335-64.

Redd, Steven B. 2004. "Satisficing Guaranteed?: An Experimental Examination of Decision Strategies and Choice in Foreign Policy Crises." Working paper. University of Wisconsin-Milwaukee.

Redd, Steven B. 2005. "United States of America." In *Defense and Security: A Guide to National Armed Forces and Security Policies of the World*, eds. Karl R. DeRouen and Uk Heo. Santa Clara, CA: ABC-CLIO.

Riggle, Ellen D. B., and Mitzi M. S. Johnson. 1996. "Age Difference in Political Decision Making: Strategies for Evaluating Political Candidates." *Political Behavior* 18: 99-118.

Ritov, Ilana, and Jonathan Baron. 1999. "Protected Values and Omission Bias." *Organizational Behavior and Human Decision Processes* 79:79-94.

Russo, J. Edward, and Barbara Anne Dosher. 1983. "Strategies for Multiattribute Binary Choice." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 9:676-96.

Sage, Andrew P. 1990. "Human Judgment and Decision Rules." In *Concise Encyclopedia of Information Processing in Systems and Organizations*, ed. Andrew P. Sage. New York, NY: Pergamon Press.

Scott, Andrew M. 1982. *The Dynamics of Interdependence*. Chapel Hill, NC: University of North Carolina Press.

Simon, Herbert A. 1955. "A Behavioral Model of Rational Choice." *Quarterly Journal of Economics* 69: 99-118.

Simon, Herbert A. 1957. *Models of Man: Social and Rational*. New York, NY: John Wiley.

Simon, Herbert A. 1990. "Alternative Visions of Rationality." In *Rationality in Action: Contemporary Approaches*, ed. Paul K. Moser. Cambridge, UK: Cambridge University Press.

Sniderman, Paul M., Richard A. Brody, and Philip E. Tetlock. 1991. *Reasoning and Choice: Explorations in Political Psychology*. Cambridge: Cambridge University Press.

Suedfeld, Peter, and Philip E. Tetlock. 1992. "Psychological Advice about Political Decision Making: Heuristics, Biases, and Cognitive Defects." In *Psychology and Social Policy*, ed. Peter Suedfeld and Philip E. Tetlock. New York, NY: Hemisphere Publishing.

Svenson, Ola, and A. John Maule, ed. 1993. *Time Pressure and Stress in Human Judgment and Decision Making*. New York, NY: Plenum Press.

Taber, Charles S., and Marco R. Steenbergen. 1995. "Computational Experiments in Electoral Behavior." In *Political Judgment*, eds. Milton Lodge and Kathleen M. McGraw. Ann Arbor: University of Michigan Press.

Tetlock, Philip E. 1983. "Psychological Research on Foreign Policy: A Methodological Overview." In *Review of Personality and Social Psychology*, vol. 4, edited by Ladd Wheeler and Phillip Shaver. Beverly Hills, CA: Sage.

Tetlock, Philip E. 1992. "The Impact of Accountability on Judgment and Choice: Toward a Social Contingency Model." In *Advances in Experimental Social Psychology*, ed. Mark P. Zanna. San Diego, CA: Academic Press.

Tetlock, Philip E., and Richard Boettger. 1989. "Accountability: A Social Magnifier of the Dilution Effect." *Journal of Personality and Social Psychology* 57: 388-98.

Tetlock, Philip E., Orie V. Kristel, S. Beth Elson, Melanie C. Green, and Jennifer S. Lerner. 2000. "The Psychology of the Unthinkable: Taboo Trade-offs, Forbidden Base Rates, and Heretical Counterfactuals." *Journal of Personality and Social Psychology* 78:853-70.

Tversky, Amos and Daniel Kahneman. 1981. "The Framing of Decisions and the Psychology of Choice." *Science* 211: 453-58.

Vertzberger, Yaacov Y. I. 1990. *The World in Their Minds: Information Processing, Cognition, and Perception in Foreign Policy Decisionmaking*. Stanford, CA: Stanford University Press.

Zey, Mary. 1992. *Decision Making: Alternatives to Rational Choice Models*. Newbury Park, CA: Sage Publications.

Zinnes, Dina A. 1966. "A Comparison of Hostile Behavior of Decision Makers in Simulate and Historical Data." *World Politics* 18:474-502.

Appendix A

The Scenario

Administration Decision: Combating Terrorism

During the past several weeks the media has focused heavily on the Administration's upcoming decision regarding its choice whether to pursue various advanced technologies aimed at combating terrorism in the future. Since the events of September 11, 2001, the Administration has been undertaking steps to detect and combat terrorists and terrorist acts committed here in the United States. The Administration, in cooperation with various research centers and laboratories, has been looking to develop several new futuristic advanced technologies designed to detect weapons of mass destruction (WMD).

However, not all of the technologies can be implemented in the future. A choice must be made. As a chief Administration official, you must decide what to do. The decision has military, economic, and political implications. The military dimension deals with how the proposed technologies would aid the armed services in dealing with potential uses of WMD on American soil. The economic dimension addresses the total costs of each technology in terms of research and development as well as implementation. The political dimension deals with how your choice of the new technology will be received by Congress and the American public.

At the present time, because of the war on terrorism, there is approximately a 90% chance that Congress will fund at least one of these options. Congress has committed verbally and in writing to do whatever it takes to protect the American public from terrorism.[1]

The following alternatives have been identified:

- *Border Crossing Sensors:* Introduce environmental monitors that can trace whether chemical or biological weapons have been set off. Using EPA monitoring stations, these monitors sample the air for traces of chemical and biological toxins.
- *Environmental Monitors:* Introduce sensors that can be used at border crossings in order to detect whether terrorists are attempting to smuggle chemical or biological weapons into the country.
- *Local Emergency Responders:* Provide local emergency responders with radiological detection equipment.
- *Do Nothing:* Decide not to proceed with implementing any particular system at this time.

At this stage there is a high level of certainty that these future technologies will be successful and will work as conceived of and designed. Many in the scientific community are encouraged by the progress made so far and are hopeful that these options and the technology associated with them will actually work.[2]

The decision board will indicate how each of these options is evaluated along various relevant dimensions. These written evaluations are also summarized as a rating on a 21-point scale (-10 implies that an option is evaluated very unfavorably, 0 implies a neutral position, and 10 implies a very favorable evaluation of the option).

[1] Negative frame reads as follows: At the present time, because of the recent war in Iraq, there is approximately a 10% chance that Congress will not fund any of these options. Congress may be constrained in its spending because of a weak domestic economy and the ongoing war in Iraq and the cost of the war approaching $100 billion.

[2] Uncertainty manipulation reads as follows: At this stage there is a high level of uncertainty about whether these future technologies will be successful and will work as conceived of and designed. Many in the scientific community are skeptical about the progress made so far and doubt that these options and the technology associated with them will actually work.

A decision has to be made! Please begin the computer simulation to explore the evaluations of the alternatives along the various dimensions and then determine your choice.

As with all "real-life" decisions, there is a tradeoff between the amount of information you consider and the time it takes you to make a decision based on that information.

Taking too much time to review the evaluations may be costly. Remember that you can only access a particular "box" of information once.

Press “CONTINUE” to start the decision process.

Appendix B

Decision Matrix for the Administration Decision

Alternatives

Dimension	Border Crossing Sensors	Environmental Monitors	Local Emergency Responders	Do Nothing
Military	"Deploying sensors at border crossings is a positive step in the prevention of terrorism in the United States. This also provides the military with a concrete location in which to concentrate its antiterrorism activities." I would rate this alternative as: **4**	"Deploying environmental monitors could help in the detection of terrorist activity; however, simply 'monitoring' the release of chemical/biological toxins may be too little, too late. The military tends to favor 'preventing' terrorist activities, rather than simply detecting them." I would rate this alternative as: **1**	"Using local emergency responders allows the military to correlate antiterrorism activities with local communities. This provides for a more 'comprehensive' antiterrorism shield for the United States." I would rate this alternative as: **7**	"Doing nothing in this case is unwise. The military must prepare now to address the possible threat of terrorist action here in the United States. If we fail to act now we will be subjecting the United States to a grave security threat." I would rate this alternative as: **-8**
Economic	"This option would most likely be cost prohibitive. The U.S. has long borders with both Mexico and Canada and trying to cover the thousands of miles with each is more than we can afford." I would rate this alternative as: **-4**	"Deploying environmental monitors throughout the United States in most major cities would be entirely too expensive, running into the billions and billions of dollars." I would rate this alternative as: **-8**	"This option is more cost effective since local communities and actors could help bear the cost of fighting the war on terrorism." I would rate this alternative as: **3**	"From an economic standpoint this is the best option. Economic resources would be better spent in targeting terrorists in their overseas locations." I would rate this alternative as: **10**
Political	"Protecting our borders is a very visual sign of the war on terror and will make U.S. citizens feel safer." I would rate this alternative as: **5**	"This will show that the U.S. is seriously committed to the war on terrorism. Environmental monitors show the public that we will do whatever it takes to protect our people." I would rate this alternative as: **9**	"This option will not be looked upon favorably by local governments since they will have to contribute resources to the war on terror. Likewise, this may put undue burdens on the public within their local communities." I would rate this alternative as: **-5**	"A case can also be made to the public for doing nothing at this time. The other three technology options are unproven and untried on a nation-wide scale at this point in time and the public may prefer to take the wait-and-see approach." I would rate this alternative as: **8**

Appendix C

Decision Making Under Conditions of Uncertainty: Experimental Assessment of Decision Models ¾ Follow-up Experimental Analysis

Steven B. Redd
Department of Political Science
University of Wisconsin-Milwaukee

Mark Davis
National Defense University

METHODS

Subjects

Thirty-three officers at National Defense University (NDU) participated in the second phase of the experiment.[1] The officers were recruited from a leadership course taught over two semesters at NDU and were some of the same officers who participated in the first phase of the experiment. These officers represented all four branches of the U.S. armed forces, and several branches of the Reserve and National Guard. The study used the decision board platform (Version 4.0) as a "process tracer." The subjects were randomly assigned to one of four experimental conditions.

Design

As in the original study, a 2 X 2 between-groups factorial design was employed. The two factors were as follows: (1) Framing of likelihood of funding (positive vs. negative), and (2) Certainty effects (certain that technology will function vs. uncertain).

The primary goal of this analysis was to determine if and how NDU military subjects change decision strategies and choices as a consequence of leadership courses taken at the National Defense University. Three notes of importance: (1) the second phase analysis was not designed as a within-subjects design, i.e., subjects did not participate in the exact same conditions in phases one and two, but were instead randomly assigned in the second phase to one of the four conditions; (2) not all of the original 53 respondents in phase one participated in phase two, wherein 33 subjects participated, and (3) one of the conditions in phase two had only 5 subjects; therefore, any conclusions regarding the specific results for phase two or for the comparisons between phases one and two should be considered tentative. This second phase of the examination of NDU military subjects did yield several interesting results.

RESULTS

As was the case in the original study, the data analysis focused on determining how the framing of the likelihood of funding antiterrorism measures from Congress and the degree of certainty concerning the functionality of these antiterrorism measures influenced strategy selection and choice, as well as how decision processes themselves affected choice. This second phase of the study also concentrated on comparing any differences between the first phase of those participating in the study at the National Defense University with those participating in the second phase.

Framing, Certainty, Strategy Selection, and Choice

We present significant results concerning first, the second phase of the NDU subjects, and second, the comparisons between the first and second subject pools at the National Defense University. Before doing so it is important to note that the manipulations for framing and certainty did not work in the second phase of the experiment. For the military subjects in the second phase, the framing manipulation was not significant $F(1, 29) = 1.24$ $p < .274$, positive frame ($M = 7.84$), negative frame ($M = 6.79$). The certainty manipulation for the military subjects was also not significant $F(1, 29) = .782$ $p < .384$, certain ($M = 7.00$), uncertain ($M =$

[1]Previous experimental/simulation research in international affairs also used students to test specific decision hypotheses (see Beer et al. 1987; Boettcher 1995). Zinnes (1966) replicated World War I decisions in a simulation study using high school students. Mintz, Geva, and Redd (1995), using the Foreign Policy Decision Board Platform, obtained similar results using both college students and Air Force commanders (see also Mintz et al. 1997). Of course, we are not asserting that students operating in an experimental setting equal the high level, real-world context of foreign policy decision making. Instead, we are arguing that experimental simulations of these actual, real-world foreign policy settings can provide insights into the ways in which advisers can influence national security-level decision making. See Tetlock (1983) for a discussion of the strengths and weaknesses associated with experimental research in the social sciences.

5.78). The means were in the right direction but not statistically significantly different. We would add the caveat that one of the conditions only had five participants so the results could be a function of this rather low count.

NDU Military Subjects: Second Phase

Using ANOVA methods and the Search Index (SI), we found no significant effects of framing or certainty on the use of alternative or dimension-based strategies. However, in contrast to the first phase, we did find marginally significant results for noncompensatory strategies by alternative and for the number of cells accessed. We found a main effect for certainty on the use of noncompensatory strategies $F(1, 29) = 3.06$ $p < .09$. Faced with certain technology, subjects tended to use more noncompensatory strategies ($M = 4.33$) while those faced with uncertainty used more compensatory strategies ($M = 2.72$). When it was certain that the technology would work, subjects were less willing to engage in compensatory strategies. Perhaps they had made up their minds on which alternative to pursue and they did not want to compare and contrast alternatives to one another. There was also an interaction effect between framing and certainty on the use of noncompensatory strategies $F(1, 29) = 3.73$ $p < .06$. The positive, certain ($M = 3.10$) and positive, uncertain ($M = 3.33$) conditions were quite similar but the negative, certain ($M = 6.80$) and negative, uncertain ($M = 2.11$) conditions were very different. Again, those in the certain condition and faced with a negative frame were much more likely to employ noncompensatory strategies than were those faced with certainty and a negative frame. There was also a close to significant interaction effect between framing and certainty on the number of cells accessed $F(1, 29) = 3.99$ $p < .06$ with the following means per condition: positive, certain ($M = 8.30$), positive, uncertain ($M = 5.56$), negative, certain ($M = 4.80$), and negative, uncertain ($M = 8.22$). The two "extreme" conditions led subjects to acquire more information.

Using the z test for proportions we also found a significant main effect between framing and the decision strategy used, i.e., alternative versus dimension-based procedures, and subjects making the "correct" choice (defined as multiplying the numerical rating of the alternative by the subject's own rating of a given dimension) ($z = 2.22$ $p < .02$). Twenty-nine percent of the subjects using alternative-based strategies were able to make the correct choice while only 9 percent using dimension-based strategies were able to do so (see Table 1). We also found a main effect for certainty and correct choice ($z = 1.96$ $p < .03$). Specifically, 27 percent of those subjects using alternative-based strategies were able to make the correct choice, while only 7 percent of those using dimension-based processes were able to do so (see Table 2). In other words, regardless of the framing or certainty condition, subjects using alternative-based procedures were more likely to make the correct choice compared to those using dimension-based processing. These findings are similar to previous findings wherein subjects using alternative-based strategies were better able to make "correct" choices (Ford et al. 1989; Payne, Bettman and Johnson 1988, 1993; Redd 2002).

Table 1. Effect of Decision Strategy on Choice in the Context of Framing (National Defense University Military Subjects ¾ Second Phase)

Decision Strategy	
Alternative-based	**Dimension-based**
29%	9%

Table 2. Effect of Decision Strategy on Choice in the Context of Certainty (National Defense University Military Subjects ¾ Second Phase)

Decision Strategy	
Alternative-based	**Dimension-based**
27%	7%

We also found a main effect for framing and the use of compensatory versus noncompensatory decision making ($z = 2.20$ $p < .02$) wherein those using compensatory strategies, regardless of a positive or negative frame, made the correct choice 17 percent of the time while those using noncompensatory strategies were unable to make the correct choice at all (0%) (see Table 3). We also found a main effect between certainty and the use of compensatory versus noncompensatory strategies ($z = 2.16$ $p < .02$) wherein those using compensatory strategies were able to choose correctly 15 percent of the time while those using noncompensatory strategies again failed to choose accurately (0%) (see Table 4). Again, these findings support previous results that showed that subjects using compensatory strategies were often better able to make "correct" choices (Redd 2002).

Table 3. Effect of Decision Strategy on Choice in the Context of Framing (National Defense University Military Subjects ¾ Second Phase)

Decision Strategy	
Compensatory (by dimension)	**Noncompensatory (by dimension)**
17%	0%

Table 4. Effect of Decision Strategy on Choice in the Context of Certainty (National Defense University Military Subjects ¾ Second Phase)

Decision Strategy	
Compensatory (by dimension)	**Noncompensatory (by dimension)**
15%	0%

NDU First Phase-NDU Second Phase Military Subjects Comparison

We compared NDU first phase subject responses with NDU second phase subject responses and generated the following results. There were no significant differences between the subjects in the two phases with respect to "doing something" versus "doing nothing," between maximizing versus satisficing strategies, or between compensatory versus noncompensatory processing.

Using ANOVA methods we did find a statistically significant difference between the two groups for the average number of cells accessed overall $F(1, 81) = 5.08$ $p < .03$, with subjects in the first phase accessing a mean of 9.04 cells (a median 9 cells), and subjects in the second phase only accessing on average 7.00 cells (also the median). Even though several months had transpired between the subjects' first exposure to the decision task and their second encounter, they needed less information en route to their choice. It is also certainly plausible that the leadership course taken by the subjects at the National Defense University also contributed to their ability to make decisions with less information. We also found marginally significant differences in the average number of cells accessed when subjects were faced with positive framing $F(1, 42) =$

3.34 $p < .07$. Subjects in the first phase had a mean access rate of 9.24 cells (9 median) while those in the second phase only accessed an average of 7 cells (7 median).

There was a also a statistically significant difference in the amount of time taken by subjects to access information in the two phases in terms of total number of seconds $F(1, 81) = 18.41$ $p < .0001$, where subjects in the first phase had a mean access time of 485.22 seconds while those in the second phase took only an average of 304.21 seconds accessing information. NDU subjects in the second phase not only accessed less information, but they also needed less time to choose among the available alternatives. Again, the leadership training at National Defense University may have led to this result. We also obtained significant results for time taken in each of the specific conditions: positive framing $F(1, 42) = 13.20$ $p < .0008$, 1st phase ($M = 523.6$), 2nd phase ($M = 301.26$); negative framing $F(1, 37) = 5.83$ $p < .02$, 1st phase ($M = 446.84$), 2nd phase ($M = 308.21$); certainty $F(1, 39) = 10.72$ $p < .002$, 1st phase ($M = 530.39$), 2nd phase ($M = 308.87$); uncertainty $F(1, 40) = 7.20$ $p < .01$, 1st phase ($M = 436.29$), 2nd phase ($M = 300.33$).

We also found differences in the Search Indexes for the two groups. Under certain conditions we found a marginally significant result $F(1, 39) = 3.35$ $p < .07$, where in the first phase subjects tended to pursue dimension-based strategies ($M = -0.165$) while those in the second phase employed more alternative-based strategies ($M = 0.332$). The finding for uncertain conditions was conventionally significant $F(1, 40) = 7.20$ $p < .01$, wherein subjects in the first phase operated by alternative ($M = 0.418$) while those in the second phase operated by dimension ($M = -0.037$). In the first phase of the experiment, subjects changed strategies depending upon the certainty with which the antiterrorism technologies were likely to succeed. When the alternatives were certain to succeed, the subjects preferred to access information by dimension, but when the technology was uncertain, subjects accessed information along each alternative. In the former, it appears that the subjects simply wanted to evaluate the alternatives based on their political, economic, and military utility, but when the technologies were uncertain, subjects endeavored to gain more information about each alternative in and of itself. In the second phase, subjects reverted to more typical decision strategies wherein they reduce cognitive strain in the uncertain conditions by resorting to dimension-based strategies (Russo and Dosher 1983).

Finally we found a significant difference between the two groups with respect to noncompensatory decision making by dimension under uncertain conditions $F(1, 40) = 4.52$ $p < .04$, with subjects in the first phase using more compensatory strategies ($M = 0.500$), with subjects in the second phase still using compensatory strategies but to a lesser degree ($M = 1.667$). This result is further evidence that subjects in the second stage used more typical cognitive strain reducing strategies en route to choice.

Conclusion

Unlike the first phase there were no significant results in the second group for the influence of framing or certainty on alternative vs. dimension-based processing. We did find significant differences between the two groups in alternative vs. dimension-based strategies under certain and uncertain conditions. The first group used dimension-based processes when faced with certainty and alternative-based strategies under uncertain conditions. The second group did just the opposite. Subjects in the second phase were also marginally influenced by certainty in using compensatory vs. noncompensatory decision strategies. They tended to employ noncompensatory strategies when faced with certainty and compensatory strategies when encountering uncertainty.

Whereas in the first group we tended to find main effects for framing or certainty and for interaction effects on correct choices, in the second group most of the results were main effects for decision strategy. Overall, subjects using alternative-based and compensatory strategies were able to make the correct choice while those employing dimension-based and noncompensatory strategies were much less likely to make the correct choice.

We also found fundamental differences between the first and second groups in terms of time taken to access information and in the average number of cells accessed. Overall, subjects in the second phase tended to access less information and to take less time in making their decision. One could argue that this is merely an artifact of the fact that subjects were already familiar with the experimental task and platform so they used prior memory to help them make their decision instead of the information contained in the decision board.

While this is certainly a plausible argument and may be a contributing factor, we would point out that quite a few months transpired between the first and second phases of the experiment, limiting what the subjects would be able to specifically recall from their first experience with the decision board. What this can demonstrate is that when subjects are somewhat familiar with a choice task as a result of prior experience then we might expect them to require less information and to take less time in a subsequent choice task. Further research would benefit from exploring this phenomenon in greater detail and in repeated trials.

Along these lines, we feel that both phases of the experimental study of military subjects at National Defense University offer some constructive applied lessons for decision makers operating in the real world of uncertainty and attempts by others to frame decision tasks. Perhaps the first lesson learned, regardless of certainty or uncertainty and positive vs. negative framing, is that experienced decision makers, such as the military officers at National Defense University, tend to prefer to "do something" even when "doing nothing" is an option and, in fact, even when it is the highest rated option (see Appendix B). This may be a function of the fact that this decision was basically a budgeting decision and it may be that experienced decision makers "never leave money on the table." It could also be a function of the belief that in the "war on terrorism" it is better to pursue some solution than to put off making a decision for the foreseeable future. Directors, administrators, leaders and decision makers in general can make use of these tendencies when structuring decision tasks. For example, if an administrator is presenting alternatives for adoption to a superior or some other decision-making group he or she could structure the choice set so as to increase the likelihood that one or another option is selected as opposed to a lesser-preferred alternative or alternatives.

Also, we see that when the military decision makers were initially faced with uncertainty in the first phase of the experiment they employed alternative-based processes in searching for information. This would imply their desire to familiarize themselves to a greater degree with antiterrorism technology since they were told that the technology was uncertain to be successful. However, in the second phase, when they were more familiar with the technology because of repeating the experimental simulation, they switched to more dimension-based strategies. This finding is interesting when we factor in what kinds of strategies lead to correct choices. Overall, subjects employing alternative and compensatory strategies were better able to make correct choices. While experienced decision makers often resort to cognitive shortcuts such as dimension-based and noncompensatory strategies, it seems that they tend to make better choices when they employ more maximizing-type strategies such as alternative-based and compensatory processes (Herek, Janis, and Huth 1987). Again, those individuals in control of information, e.g., commanders, leaders, etc. might take these findings to heart. If group members receive too much information up front or if they are already familiar with the alternatives of a decision task they may be inclined to satisfice and undertake other cognitive shortcuts. Doing so may reduce the quality of their decisions.

REFERENCES

Aronson, Elliot, and J. Merrill Carlsmith. 1968. "Experimentation and Social Psychology." In *The Handbook of Social Psychology*, ed. Gardner Lindzey and Elliot Aronson. Reading, MA: Addison-Wesley.

Astorino-Courtois, Allison. 2000. "The Effects of Stakes and Threat on Foreign Policy Decision-Making." *Political Psychology* 21:489-510.

Beer, Francis A., Alice F. Healy, Grant P. Sinclair, and Lyle E. Bourne, Jr. 1987. "War Cues and Foreign Policy Acts." *American Political Science Review* 81:701-15.

Billings, Robert S., and Lisa L. Scherer. 1988. "The Effects of Response Mode and Importance on Decision-Making Strategies: Judgment Versus Choice." *Organizational Behavior and Human Decision Processes* 41:1-19.

Boettcher, William A., III. 1995. "Context, Methods, Numbers, and Words: Prospect Theory in International Relations." *Journal of Conflict Resolution* 39:561-83.

Ford, J. Kevin, Neal Schmitt, Susan L. Schechtman, Brian M. Hults, and Mary L. Doherty. 1989. "Process Tracing Methods: Contributions, Problems, and Neglected Research Questions." *Organizational Behavior and Human Decision Processes* 43: 75-117.

Herek, Gregory, Irving Janis, and Paul Huth. 1987. "Decision Making During International Crises: Is Quality of Process Related to Outcome?" *Journal of Conflict Resolution* 31:203-26.

Mintz, Alex, and Nehemia Geva. 1997. "The Poliheuristic Theory of Foreign Policy Decision Making." In *Decisionmaking on War and Peace: The Cognitive-Rational Debate*, eds. Nehemia Geva and Alex Mintz. Boulder, CO: Lynne Rienner.

Mintz, Alex, Nehemia Geva, and Steven B. Redd. 1995. "The Impact of Dynamic and Static Choice Sets on Decision Strategy: An Analysis Utilizing the Decision Board Platform." Paper presented at the annual meeting of the International Studies Association, Chicago, Illinois, February 22-25.

Mintz, Alex, Nehemia Geva, Steven B. Redd, and Amy Carnes. 1997. "The Effect of Dynamic and Static Choice Sets on Political Decision Making: An Analysis Using the Decision Board Platform." *American Political Science Review* 91: 553-66.

Payne, John W. 1976. "Task Complexity and Contingent Processing in Decision Making: An Information Search and Protocol Analysis." *Organizational Behavior and Human Performance* 16:366-87.

Payne, John W., James R. Bettman, and Eric J. Johnson. 1988. "Adaptive Strategy Selection in Decision Making." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 14: 534-52.

Payne, John W., James R. Bettman, and Eric J. Johnson. 1993. *The Adaptive Decision Maker*. Cambridge: Cambridge University Press.

Redd, Steven B. 2002. "The Influence of Advisers on Foreign Policy Decision Making: An Experimental Study." *Journal of Conflict Resolution* 46:335-364.

Russo, J. Edward, and Barbara Anne Dosher. 1983. "Strategies for Multiattribute Binary Choice." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 9:676-96.

Tetlock, Philip E. 1983. "Psychological Research on Foreign Policy: A Methodological Overview." In *Review of Personality and Social Psychology*, vol. 4, edited by Ladd Wheeler and Phillip Shaver. Beverly Hills, CA: Sage.

Zinnes, Dina A. 1966. "A Comparison of Hostile Behavior of Decision Makers in Simulate and Historical Data." *World Politics* 18:474-502.

Arnold Vedlitz, Alex Mintz, Steven B. Redd, Xinsheng Liu, and Letitia T. Alston. *Decision Making Under Conditions of Uncertainty: Experimental Assessment of Decision Models.* (March 2005). A report to the National Defense University by the Institute for Science, Technology and Public Policy in the George Bush School of Government and Public Service, Texas A&M University.