THE EFFECTS OF ALTERNATIVE PRESENTATION FORMATS ON
BIASES AND HEURISTICS IN
HUMAN DECISION MAKING

DISSertation

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Thomas P. Van Dyke, B.S., M.B.A.
Denton, Texas
May, 1996
THE EFFECTS OF ALTERNATIVE PRESENTATION FORMATS ON
BIASES AND HEURISTICS IN
HUMAN DECISION MAKING

DISSERTATION

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Thomas P. Van Dyke, B.S., M.B.A.

Denton, Texas

May, 1996

The purpose of this research was to determine whether changes in the presentation format of items in a computer display could be used to alter the impact of specific cognitive biases, and to add to the knowledge needed to construct theory-based guidelines for output design. The problem motivating this study is twofold. The first part of the problem is the sub-optimal decision making caused by the use of heuristics and their associated cognitive biases. The second part of the problem is the lack of a theoretical basis to guide the design of information presentation formats to counter the effects of such biases.

An availability model of the impact of changes in presentation format on biases and heuristics was constructed based on the findings of a literature review. A six-part laboratory experiment was conducted utilizing a sample of 205 student subjects from the college of business. The independent variable was presentation format which was manipulated by altering the visual salience or visual recency of items of information in a visual computer...
display. The dependent variables included recall, perceived importance, and the subjects’ responses to three judgment tasks.

The results clearly demonstrate that changes in presentation format can be used to alter the impact of cognitive biases on human decision making. The results also provide support for the availability model, with the exception of the proposed influence of learning style. Learning style was found to have no significant impact on decision making whether alone or in combination with changes in presentation format.

The results of this investigation demonstrate that by using our knowledge of cognitive processes (e.g., the visual salience effect, the visual recency effect, and the availability heuristic), presentation formats can be altered in order to moderate the effects of certain biases and heuristics in human decision making. An understanding of these results may be useful in improving DSS design.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vii</td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Purpose</td>
<td>2</td>
</tr>
<tr>
<td>Problem</td>
<td>3</td>
</tr>
<tr>
<td>Significance</td>
<td>5</td>
</tr>
<tr>
<td>Limitations of the Study</td>
<td>10</td>
</tr>
<tr>
<td>Definitions of Key Terms</td>
<td>14</td>
</tr>
<tr>
<td>Chapter Introductions</td>
<td>16</td>
</tr>
<tr>
<td>Chapter References</td>
<td>18</td>
</tr>
<tr>
<td>2. BACKGROUND</td>
<td>22</td>
</tr>
<tr>
<td>Decision Making</td>
<td>22</td>
</tr>
<tr>
<td>Normative Decision Making</td>
<td>22</td>
</tr>
<tr>
<td>Behavioral Decision Making</td>
<td>24</td>
</tr>
<tr>
<td>Biases and Heuristics</td>
<td>27</td>
</tr>
<tr>
<td>Base-Rate Fallacy</td>
<td>27</td>
</tr>
<tr>
<td>Framing Effect</td>
<td>29</td>
</tr>
<tr>
<td>Anchoring-And-Adjustment Heuristic</td>
<td>31</td>
</tr>
<tr>
<td>Examples of the Use of Heuristics</td>
<td>32</td>
</tr>
<tr>
<td>Debiasing</td>
<td>39</td>
</tr>
<tr>
<td>Graphic Displays</td>
<td>40</td>
</tr>
<tr>
<td>Effects of Presentation Format on Decision Making</td>
<td>41</td>
</tr>
<tr>
<td>Visual Salience</td>
<td>44</td>
</tr>
<tr>
<td>Visual Recency</td>
<td>47</td>
</tr>
<tr>
<td>Availability</td>
<td>49</td>
</tr>
<tr>
<td>Recall</td>
<td>53</td>
</tr>
<tr>
<td>Individual Differences</td>
<td>58</td>
</tr>
<tr>
<td>Chapter References</td>
<td>64</td>
</tr>
<tr>
<td>3. THEORETICAL FRAMEWORK AND HYPOTHESES</td>
<td>73</td>
</tr>
<tr>
<td>Model Development</td>
<td>73</td>
</tr>
<tr>
<td>Description of the Model</td>
<td>86</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>90</td>
</tr>
<tr>
<td>Chapter References</td>
<td>95</td>
</tr>
<tr>
<td>4. RESEARCH DESIGN</td>
<td>98</td>
</tr>
<tr>
<td>General</td>
<td>98</td>
</tr>
<tr>
<td>Subjects</td>
<td>100</td>
</tr>
<tr>
<td>Measures</td>
<td>101</td>
</tr>
</tbody>
</table>
LIST OF TABLES

1. Hypothesis and related portions of the experiment . 100
2. Variable Analysis Table: Phase I.A 109
3. Variable Analysis Table: Phase I.B 112
4. Variable Analysis Table: Phase I.C 115
5. Variable Analysis Table: Phase II.A 117
6. Variable Analysis Table: Phase II.C 120
7. Demographics 126
8. VVQ: Descriptive Statistics 129
9. Learning Style: Combined Groups 130
10. Phase I.A: Base-Rate Neglect
    Main and Interaction Effects 132
11. Phase I.A: Base-Rate Neglect
    ANOVA between PIE and PICT 132
12. Phase I.A: Base-Rate Neglect
    ANOVA between GRAPHIC and NOGRAPHIC 132
13. Framing Effect - Proportions and Cell Sizes 137
14. Framing Effect - Mean Ratings and Cell Sizes 138
15. Phase I.B: Framing Effect
    Main and Interaction Effects 138
16. Phase I.C: Anchoring-and-Adjustment
    Main and Interaction Effects 141
17. Phase II.A: Perceived Importance
    ANOVA between GRAPHIC and NOGRAPHIC 144
18. Phase II.A: Mann-Whitney U test Perceived Relative
    Importance (rankings) of the base rate between
    GRAPHIC and NOGRAPHIC treatments 144
19. Summary of Results 152
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Graph A: O-ring Failures</td>
<td>8</td>
</tr>
<tr>
<td>2.</td>
<td>Graph B: O-ring Failures</td>
<td>8</td>
</tr>
<tr>
<td>3.</td>
<td>Graph C: O-ring Failures</td>
<td>9</td>
</tr>
<tr>
<td>4.</td>
<td>Availability Model</td>
<td>74</td>
</tr>
<tr>
<td>5.</td>
<td>Framework for the Use of Graphics as Decision Aids</td>
<td>75</td>
</tr>
<tr>
<td>6.</td>
<td>Cognitive Fit - Problem Solving Model</td>
<td>80</td>
</tr>
<tr>
<td>7.</td>
<td>General Judgment Model</td>
<td>84</td>
</tr>
<tr>
<td>8.</td>
<td>Biases and Heuristics</td>
<td>86</td>
</tr>
<tr>
<td>9.</td>
<td>VVQ-Frequency Distributions</td>
<td>128</td>
</tr>
<tr>
<td>10.</td>
<td>Base-Rate Neglect: Frequency Distributions</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>NOGRAPHIC</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Base-Rate Neglect: Frequency Distributions GRAPHIC</td>
<td>133</td>
</tr>
<tr>
<td>12.</td>
<td>Framing Effect - Proportions</td>
<td>138</td>
</tr>
<tr>
<td>13.</td>
<td>Framing Effect - Ratings</td>
<td>139</td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION

One of the primary purposes of an information system is to support decision-making functions in the organization (Davis and Olson 1985). In order to optimize support for decision making, information should be presented to the user in a format which supports the strategies, or processes, required to perform each specific decision-making task (Vessy, 1991). Unfortunately, managers must often make decisions under conditions of uncertainty for which no formal decision strategy is optimal. Under these conditions, decision makers often resort to the use of heuristics in order to simplify the decision-making task. The use of these heuristics can lead to biases in decision making (Tversky and Kahneman 1974). Concern over the potential problems associated with these biases has led researchers to call for the development of decision aids which will reduce the impact of cognitive biases (Benbasat and Taylor 1982; DeSanctis 1984; Schwenk 1988; Weber and Coskunoglu 1990).

Decision aids in business often take the form of computer generated reports or displays (Jarvenpaa 1990). The use of graphics as part of these decision aids has become ubiquitous (Rockhold 1981; Cogen 1984; Rao 1985;
Crutchfield 1986). Modern graphics software packages provide the designers of decision support systems with the ability to produce sophisticated reports and displays which may include a wide variety of both textual and graphical formats. Several studies have demonstrated that changes in presentation format affect the selection of information acquisition and decision-making strategies (Bettman and Kakkar 1977; Bell 1984; Jarvenpaa 1989; 1990; Benbasat and Dexter 1985; Todd and Benbasat 1991). This suggests that the proper design of presentation formats might moderate the impact of heuristics and their associated biases. While researchers acknowledge the need for decision aids to counter the effects of cognitive biases, the basic research into the effects of changes in presentation format on the use of heuristics and biases has not been conducted.

Purpose

The purpose of this research was to examine the impact of information presentation format on the biases and heuristics used when making decisions under conditions of risk or uncertainty. This research seeks to determine whether changes in the visual salience or visual recency of items in a computer display could be used to alter the impact of specific cognitive biases. In addition, this research attempted to add to the knowledge needed to construct theory-based guidelines for output design.
The research question investigated by this study is "Can changes in presentation format be used to alter the effects of cognitive biases in human decision making?"

Problem

Many managerial decisions are made under conditions of risk or uncertainty. These types of decisions require the decision maker to assess the probability of an uncertain event or the value of an uncertain quantity. Tversky and Kahneman (1974) describe heuristics which decision makers use to reduce the complex tasks of assessing probabilities and predicting uncertain values into simpler judgmental operations. Among these heuristics are representativeness and anchoring-and-adjustment. The use of these heuristics can lead to systematic errors or biases in judgment (Tversky and Kahneman 1974). Research suggests that biases and heuristics identified in a laboratory context may impact several types of business decisions including such diverse activities as strategic planning (Barnes 1984; Schwenk 1988), retail buying and sales projections (Cox and Summers 1987), auditing (Joyce and Biddle 1981; Schwenk 1988), business failure analysis (Dube-Rioux and Russo 1988), the replacement of durable goods (Cripps and Meyer 1994), the evaluation of product bundles (Yadav 1994), evaluating marketing programs (Mowen and Gaeth 1992), corporate budget forecasting (Walker and McClelland 1991) and real estate
pricing (Northcraft and Neal 1987). Cox and Summers (1987) found that when making sales projections, experienced retail buyers displayed similar biases and used the same types of heuristics as found for naive subjects in previous psychological research. Northcraft and Neal (1987), in a study of real estate pricing decisions, showed that both amateurs and experts are susceptible to biases in estimation attributable to the anchoring-and-adjustment heuristic.

The potential negative impacts from biases in business decision making have prompted researchers to call for the development of decision aids to counter the effects of these cognitive biases (Benbasat and Taylor 1982; DeSanctis 1984; Schwenk 1988 Weber and Coskunoglu 1990). Decision aids in business today often take the form of computerized decision support systems (Jarvenpaa 1990). These systems employ sophisticated graphics software which gives the system designer great flexibility in selecting the presentation mode for information. Research has shown that the format of the information display affects how information is used in the decision process (Bettman and Kakkar 1977; Bell 1984; Jarvenpaa 1989; 1990; Benbasat and Dexter 1985; Todd and Benbasat 1991). However, in order to purposefully moderate a cognitive bias or influence the use of specific heuristics through changes in presentation format, one must be able to predict, a priori, the impact of changes in presentation
format on the cognitive processes underlying decision-making behavior.

The theoretical background needed to allow the designers of decision support systems (DSS) to predict the effects of changes in presentation format is limited. Todd and Benbasat (1991, 110) demonstrated that "...seemingly benign design decisions may indeed have a significant influence on subsequent behavior by systems users." The designers of decision support tools must be made aware of the possible dysfunctional effects associated with alternative presentation formats.

**Significance**

DeSanctis (1984) states that one of the key objectives of the study of graphics as decision aids is to determine how to design displays that avoid cognitive bias on the part of the reader. Unfortunately there have been no previously published studies in the Information Systems (IS) literature investigating the effects of presentation formats on cognitive biases. Furthermore, there are no reliable estimates of the costs associated with cognitive biases in decision making or the costs attributable to poorly designed information presentation formats. However, two specific examples serve to illustrate the significance of research combining these two problem areas.
A study by Eddy (1986) showed that doctors must often use probabilistic information in diagnosis. His findings indicate that physicians make major errors in probabilistic reasoning including base-rate neglect. Eddy concluded that these errors threaten the quality of medical care. For example, physicians were given a combination of prior probabilities, test results, and the known accuracy of the tests, which when correctly interpreted, indicated that the probability of a patient having cancer was 8%. About ninety-five out of one hundred physicians estimated the probability of cancer at approximately 75%. The overestimation of this probability by almost a factor of 10 can be attributed to base-rate neglect (Eddy 1986). Eddy cites an even more egregious error in a published medical report concerning the accuracy of mammography exams for diagnosing breast cancer. The physician estimated the number of false negatives at 1269 out of 10,000. Correct use of the prior probabilities however indicated that the true number of false negative indications for breast cancer is approximately 9 out of 10,000. Thus, the number of false negatives had been overestimated by a factor of about 150 (Eddy 1986). It is apparent that physicians attempting to diagnose cancer make the same cognitive bias induced errors observed in other contexts (Kahneman and Tversky 1974). This suggests that tools which reduce base-rate neglect, and
other cognitive biases, offer great opportunities for improving the quality and effectiveness of medical care.

Tufte (1995) provided a significant example of disastrous decision making which can be attributed in part to poor presentation format design. On January 27, 1986 engineers at Morton Thiokol Inc. were deeply concerned about the upcoming launch of the space shuttle Challenger. Thiokol engineers understood the relationship between temperature and the physical properties of O-ring seals. Aware of a forecast for near freezing temperatures at the launch site, the Thiokol engineers voted unanimously to recommend scrubbing the launch. To support their position, the engineers sent NASA Graph A, shown in Figure 1. Unfortunately this graph was poorly designed and made it difficult to perceive the critical relationship between temperature and O-ring failure. NASA decided to continue the launch.

On the morning of the launch, a worried engineered faxed Graph B, shown in Figure 2, to the NASA management. This graph was an improvement over Graph A but still failed to convey the salient information. The launch was attempted. O-ring failure caused by cold weather resulted in an explosion which destroyed the shuttle, claiming the lives of the Challenger crew.
History of O-Ring Damage in Field Joints (Cont)

Figure 1. Graph A: O-ring Failures

Figure 2. Graph B: O-ring Failures
Graph C (see Figure 3) was created after the disaster. This graph clearly shows the relationship between temperature and O-ring failure. It reduces the cognitive effort required to perceive and integrate the critical information (e.g., the relationship between temperature and O-ring failure). Note that Graph C clearly illustrated the fact that 100% of launches below a temperature of 65 degrees resulted in O-ring failure. The temperature on the day of the launch was 31 degrees. It is possible that had the critical information about O-ring failure and temperature been presented to the decision makers utilizing the improved presentation format represented by Graph C, the Challenger tragedy might have been avoided (Tufte 1995).

Figure 3. Graph C: O-ring Failures
The two examples cited above provide anecdotal evidence to illustrate the significance of research which may lead to a greater understanding of cognitive biases, presentation formats, and the relationship between the two. According to Jarvenpaa (1989, 299), "the main payoffs for decision aid research are likely to come from research that articulates how particular features of the aids enhance human strengths or remedies human weaknesses in extracting and using information." The Jarvenpaa (1989) study investigated the impact of specific changes to presentation formats on cognitive biases and decision processes under controlled conditions. It is anticipated that an improved understanding of the cognitive effects of changes in presentation format will provide designers of computer output used in decision making, including decision support systems, with guidance on how to present information in such a way as to moderate the potential negative impact of specific biases and heuristics.

Limitations of the Study

Considerable research has been devoted to the study of biases and heuristics in human decision making. Jacob, Gaultney, and Salvendy (1986) provide a comprehensive list of heuristics and biases which might have an impact in an information system context. The heuristics discussed by Jacob et al. include representativeness, availability, and
anchoring-and-adjustment. The biases described include ordering effects (e.g., primacy/recency), framing effects, hindsight bias, illusion of control, base-rate neglect, over confidence, and regression bias. This study will focus on only three biases: base-rate neglect, the framing effect, and insufficient adjustment associated with the anchoring-and-adjustment heuristic. These specific biases were chosen based on two attributes. First, all are well researched. Previous studies provided tasks which have been demonstrated to elicit the desired biases and heuristics. These previous studies also allow for the comparison of results. Second, all biases chosen for study can be traced to an improper assignment of importance or decision weight to specific items of information in the problem formulation.

Cleaves (1987) describes techniques for de-biasing decision makers. These techniques include providing feedback, training in corrective procedures, using formal decision-making models, and problem reformulation. This study focused on problem reformulation through changes in presentation format as a de-biasing technique.

Most of the IS research concerning presentation formats has investigated the relative efficacy of various presentation formats, i.e. tables versus graphs, for specific business tasks (DeSanctis 1984; Jarvenpaa and Dickson 1988; Hwang and Wu 1990). This study is concerned with searching for the basic attributes of a visual display
which impact decision-making biases. This necessitates focusing on a small number of manipulations of the visual presentation so as to avoid the introduction of undue complexity and possible moderating variables. Therefore, no color was used in this study since color has been shown to affect cognitive processes independent of presentation format (Benbasat and Dexter 1985). This study did not address the relative efficacy of tables versus graphs. The graphics were used solely as a method to increase the visual salience or recency of specific items of information in the visual display.

It should be noted that although the information displays used in these experiments were produced by a common graphics package, they were not part of an integrated DSS system. Each experiment and its associated presentation format dealt with a single task, and each task was considered to be independent of the others.

The stimuli used in this study were limited to knowledge lean tasks in order to minimize the effects of variations in knowledge and expertise among the subjects. Newell and Simon (1972) defines knowledge lean tasks as those for which all information needed to solve the problem is presented in the problem definition. The specific tasks selected for this study were modifications of tasks used in previous research on these same biases and heuristics. The
original questions were modified slightly to be more relevant in a business context.

The behavioral and cognitive focus of this research implies certain general limitations. Human subjects may alter their normal behavior when they know that they are being studied (e.g. the Hawthorne effect), and this can bias the results of the study. In addition, self-reported measures are also subject to bias. There can be a difference between what a person does, what they perceive, and what they report. Thus, the complexity of human behavior makes it difficult to establish cause and effect relationships. The cognitive focus of this research also imposed limitations. Psychological constructs are difficult to validate, and there is often disagreement as to the precise nature of these constructs and how they should be measured (Crocker and Algina 1986). Cognitive processes cannot be observed directly. Even process tracing methods such as protocol analysis offer only indirect measures of cognitive processes.

The choice of laboratory experimentation as a research method also implies several general limitations. One of these limitations is the conflict between experimental control and realism. Crucial variables may be excluded in the attempt to control confounding variables (Buckley, Buckley and Chang 1976). The increased control of the laboratory experiment is important for establishing internal
validity. However, it reduces the realism of the environment and external validity, or generalizability, of the results. This limitation of laboratory research does not suggest that the researcher should seek to limit control, but that care should be taken in attempting to generalize the results to a wider population (Kerlinger 1987).

Definitions of Key Terms

Many of the terms in behavioral psychology vary from study to study and also evolve over time. For example the concept of availability was first seen as a heuristic for judging frequency and probability (Tversky and Kahneman 1973). It was later extended to help explain how people make social judgments (Reyes et al. 1980). In order to avoid this type of ambiguity, the following definitions will be used throughout this investigation.

**Anchoring-and-adjustment heuristic**: A heuristic in which the decision maker starts with an initial value and adjusts from that value to reach a final estimate (Tversky and Kahneman, 1974).

**Availability**: The cognitive effort associated with the perception, integration, construction, or recall of an item. Those items with the greatest availability require the least
cognitive effort for inclusion in the decision process (Tversky and Kahneman, 1973).

**Base-rate fallacy:** An individual's tendency to ignore or neglect proportions in a general population or prior probabilities in favor of individuating information, i.e. information which applies to an individual or to a subset of the population (Bar-Hillel, 1980).

**Bias:** Systematic error in judgement associated with the use of heuristics in decision making (Tversky and Kahneman 1974).

**Framing effect:** The reversal of choices for subjects receiving different presentations of identical problem outcomes (Tversky and Kahneman 1981).

**Heuristic:** A "rule of thumb" or informal decision strategy used to simplify decision making (Tversky and Kahneman 1974).

**Recency effect:** The assignment of undue importance to the last items in a sequential presentation (Cleaves, 1987).

**Visual salience:** Visual salience refers to the differential or relative attention given to elements in the visual field
(Taylor and Thompson 1982). Visual salience is created by variations in size, shape or color.

**Chapter Introductions**

Chapter II includes a review of relevant prior research. Because there has been no prior information systems research on the effects of presentation formats on biases and heuristics, the relevant literature for several related topics is reviewed, as well as literature presented in other fields (e.g., cognitive psychology).

Chapter III includes a research framework which was developed based on the variables used in prior research related to presentation formats and decision making. The variables selected for this study and reasons for choosing those variables are discussed. Hypotheses are developed and discussed in relationship to the research framework.

Chapter IV includes a description of the research design, the subjects selected to participate, the operationalization of the variables and the development of the experimental materials. The procedures used for data collection are enumerated.

Chapter V reports the results of statistical tests of hypotheses. The results of each test are discussed and are compared to results from earlier studies. In addition, demographic data on the subjects is presented and discussed.
Chapter VI includes an analysis of the results and the significance of the findings. Limitations of this study and suggestions for future research are presented.
CHAPTER REFERENCES


CHAPTER II

BACKGROUND

There has been no prior research in the Information Systems (IS) literature investigating the effects of changes in presentation format on specific cognitive biases. However, a number of related topics have been investigated. These topics include decision making, biases and heuristics, visual salience, recency effects, the effects of computer displays on recall, and the effects of graphics in support of decision making. The current research was developed from a synthesis of variables, tasks, and theoretical frameworks used in this prior research.

Decision Making

The study of decision making can be divided into two broad categories—normative and descriptive. Normative decision-making models focus on how decisions ought to be made. Descriptive models attempt to explain the cognitive processes actually used to make decisions.

Normative Decision Making

The basis of normative decision theory is the theory of subjective expected utility. Expected utility theory defines the conditions of perfect utility maximizing rationality in situations where all variables are known with
certainty or the probability distributions of all relevant variables are known to the decision maker (Simon, 1979). Subjective expected utility theory assumes that people act in a consistent and rational manner. It assumes that each decision maker possesses a utility function which is comprised of an ordered preference among all possible outcomes of a choice. It also assumes that all alternatives available for a choice are known and that the consequences, or at least the probability distributions of the consequences, are known for each alternative. Bayes' theorem produces a model for the rational computation of subjective probabilities taking into account new or partial information. According to Simon (1987), the assumptions underlying subjective expected utility theory are required by most methods of normative decision making.

Unfortunately, the assumptions of expected utility cannot be satisfied for most complex decision situations in the real world. There are limits on human rationality. These limits are imposed by the complexity of real decision-making situations, the incompleteness of human knowledge, the inconsistency of individual preferences and beliefs, conflicts among values, and inadequacies of human computation. It is the focus on the limits of human rationality that distinguishes descriptive behavioral decision research from normative expected utility models (Simon, 1987).
Behavioral Decision Making

Behavioral decision research focuses on how people actually make decisions. Therefore, it must take into account the idea that there are limits to human information processing (Newell and Simon 1972). An underlying difference between expected utility and descriptive decision theory is the concept of the constructive nature of preferences and beliefs (Payne, Bettman, and Johnson 1992). Human beings have unstable, inconsistent, and imprecise goals because human abilities limit the orderliness of preferences (Payne et al. 1992). Constructive preferences implies that people create preferences as a response to a decision-making task. Behavioral decision research has shown that people do not construct their preferences using any consistent algorithm such as expected utility theory (Payne et al. 1992). Descriptive research on the decision-making process has shown that the information and strategies used to construct preferences and make decisions are contingent upon a variety of task, context, and individual difference variables (Payne et al. 1992). Task factors are the general characteristics of a problem which do not depend on the specific values of the alternatives. These would include the degree of structure and the response mode of the problem. Context factors, such as the similarity of the possible alternatives, are associated with the particular values of the alternatives (Payne et al. 1992). Individual
differences include such attributes as decision-making style, cognitive processing ability, and experience.

Todd and Benbasat (1991) state two objectives involved in selecting a decision-making strategy—accuracy and the reduction of cognitive effort. Given a choice between two strategies which are expected to result in the same level of accuracy, people will choose the method which minimizes cognitive effort (Johnson and Payne 1985; Todd and Benbasat 1991; Jarvenpaa, 1989). People use several methods to reduce the cognitive effort required in a decision-making problem. For example when faced with a large amount of data, people will use selective perception to narrow the field of consideration (Jacob et al. 1986). Problems which exhibit uncertainty, complexity and a lack of formal solution methods tend to lead to the use of heuristics (Tversky and Kahneman 1974; Payne, Bettman and Johnson 1992). Decision makers use heuristics or rules of thumb in order to simplify these problems. Limits on human cognition and the use of non-rigorous heuristics result in biases and inconsistencies in human decision making (Simon 1987).

A simple behavioral model for the integration of several pieces of information during judgment is described by Anderson's (1981) item integration theory. Anderson's model prescribes that information from stimulus elements (e.g., items or cues) will be integrated according to an
averaging rule to produce a judgment. This model can be described quantitatively by:

\[ J = w_1s_1 + w_2s_2 + w_3s_3 \ldots \]

where \( J \) = final judgment, \( w_i \) = weight, and \( s_i \) = a scale value associated with each item. The subscripts refer to the serial positions of the pieces of information in sequence. The weights must sum to one making this an averaging model and suggesting that decision weight is a relative and not an absolute construct. A cue's weight parameter, also known as subjective utilization, has been interpreted as reflecting the perceived relative importance of the cue (Schwartz and Norman 1989; Arkes and Hammond 1986; Weber 1994). Global interpretations of relative importance consider it to be a fixed attitude of the decision maker, a stable characteristic which is not affected by the stimuli involved. Whereas the local interpretation of relative importance holds it to be a temporary assessment that is affected by both the personal characteristics of the decision maker and the problem presentation or stimuli (Goldstein 1990). Both salience (Weber 1994; Mackenzie 1986; Creyer and Johar 1995) and order of presentation (Mackenzie 1986) have been observed to influence attribute importance weights by varying the distribution of attentional focus. Salience and order effects have been also been linked to changes in availability (Taylor and Thompson 1982). Mackenzie (1986) contends that the amount
of attention given to an attribute affects the availability of the attribute and its subsequent decision weight. Mackenzie’s contention suggests a model by which the effect of differential attention on decision weight is mediated by the availability heuristic.

**Biases and Heuristics**

Systematic errors or biases caused by the use of heuristics have been well documented in the psychology literature. For example, the representativeness heuristic can cause insensitivity to prior probabilities, also known as the base-rate fallacy (Bar-Hillel 1980). Another well researched bias is the framing effect. It occurs when people’s preferences between two outcomes are reversed due to the manner in which the problem is framed (Tversky and Kahneman 1981). Anchoring-and-adjustment biases occur when people choose inappropriate anchors or make insufficient adjustments from those anchors (Slovic and Lichtenstein 1971).

**Base-Rate Fallacy**

The base-rate fallacy occurs when people ignore or neglect base-rates in favor of individuating information (Bar-Hillel, 1980). The effect is both robust and well documented. For example, Meehl and Rosen (1955) found that when psychologists used psychological tests to estimate the probability that a case belonged to a certain category, they
tended to ignore the base-rates in the underlying population. Meehl and Rosen (1955) showed that ignoring base-rates can lead to an increase in erroneous clinical decisions.

Tversky and Kahneman (1974) also reported that people neglect population base-rates when judging the probability that an individual belongs to a certain group. They argued that the cause of the bias was the representativeness heuristic whereby people assess the probability based on the extent to which the individual's attributes are representative of, or similar to, the group. Population base-rates do not influence representativeness so the base-rates are neglected in the presence of individuating information.

Ajzen (1977) focused on causality as the key to base-rate neglect. His study concluded that people rely on information which they perceive to have a causal relation to the criterion in question while neglecting valid but non-causal data. He suggested that base rates were used only when they had causal implications. When base rates had no causal implications they would be disregarded in favor of individuating information. Bar-Hillel (1980) presented a more general theory to explain the base-rate fallacy. His research suggests that people rank information by its perceived relevance. Decision makers let high relevance data dominate that which they consider to be less relevant.
Information is judged to be more relevant when it is perceived to relate more specifically to the target case. According to Bar-Hillel, specificity can be increased in two ways. One is through the perception of causality. A second method for achieving specificity is by providing information on a subset of the overall population, of which the target case is a member.

Framing Effect

Studies of human decision making often assume rationality on the part of decision makers. Rationality implies a certain amount of consistency. However, people can be influenced by the way in which outcomes are portrayed, either positively or negatively. It is often possible to alter the frame of a decision problem by changing the way in which the problem is phrased. Rationality in decision making requires that changes in frame should not reverse a decision-maker’s preference between options (Tversky and Kahneman, 1981). When this occurs, the reversal is known as the framing effect. The framing effect has been defined by Tversky and Kahneman (1981) as the reversal of choices for subjects receiving different framings of the same problem outcomes. They demonstrated a decision problem which called for subjects to choose between two options for treating a disease which could kill 600 people. Option 1 was a sure thing, 200 people would be saved. Option 2 was a riskier alternative
which offered a one-third chance that no one would die. When the outcome was phrased positively, in terms of number of people who would live, the majority of subjects (72%) chose option 1. However, when the outcomes were phrased negatively, in terms of the number of people who would die, the majority (78%) chose the riskier option 2.

Prospect theory (Kahneman and Tversky, 1979) predicts that people will choose differently depending on whether the outcomes are perceived in terms of gains or losses. According to prospect theory, outcomes are viewed as gains or losses relative to an initial reference point. It is the perceived relative change in the value of the outcome and not the absolute magnitude of the value that influences decision making (Miller and Fagley, 1991). Prospect theory describes an S-shaped value curve that is steeper for perceived losses than for perceived gains. Therefore, the relative pain associated with a loss is greater than the pleasure associated with a gain of the same amount. This leads subjects to react differently to the same situation depending on whether the outcomes are framed as relative losses or relative gains (Levin et al., 1985).

There are several types of context manipulation that can result in a framing effect. This study focuses on a specific type of framing effect known as the "formulation effect." It is caused by a manipulation of the problem wording that alters whether identical alternative outcomes
to a problem are perceived as gains or losses (Fagley and Miller, 1990). In a study of problems exhibiting the formulation effect, Fagley and Miller (1990) searched for interaction effects with certain individual difference variables including cognitive style and risk-taking propensity. Neither cognitive style nor risk-taking propensity exhibited significant interactions with problem framing. However their study did show significant differences between individual problems indicating that the framing effect is highly task sensitive.

**Anchoring-And-Adjustment Heuristic**

A common method used to estimate uncertain quantities is the anchoring-and-adjustment heuristic. According to this procedure, the decision maker starts with an initial value and adjusts from that value to reach a final estimate (Tversky and Kahneman, 1974). This heuristic can be very economical and effective. However, two systemic errors have been identified in conjunction with anchoring-and-adjustment. The first error is the use of arbitrary or irrelevant anchors (Tversky and Kahneman, 1974). This occurs when a decision maker uses, as an initial reference point, a number with no logical relation to the quantity that is being estimated. A second potential bias is insufficient adjustment. Adjustments away from the anchor are typically insufficient resulting in estimates that are too close to the initial reference point (Slovic and
Lichtenstein, 1971). Northcraft and Neal (1987), in a study of real estate pricing decisions, showed that biases associated with anchoring-and-adjustment occur in real-world, information-rich judgment tasks. Their results also suggest that both amateurs and experts are susceptible to biases in estimation attributable to the anchoring-and-adjustment heuristic.

Examples of the Use of Heuristics

Several studies have investigated the impact of heuristics and biases in various decision-making contexts. Cox and Summers (1987) performed a laboratory experiment utilizing experienced retail buyers in order to determine whether biases due to the use of heuristics are present in the intuitive projection of retail sales. The subjects' estimates were compared against actual sales and against forecasts based on a regression model. The results of the study indicated support for Hogarth and Makridakis' (1981, 129) observation that "quantitative, and particularly simple models can outperform humans in a wide range of situations."

In addition, Cox and Summers (1987, 2295) findings suggest that "when making sales projections based in initial sales rates, experienced retail buyers display similar biases and use the same types of heuristics as found for naive subjects in previous psychological research." The heuristics identified as being used by the retail buyers when making sales projections included representativeness and anchoring-
and-adjustment. The most commonly observed bias was insufficient adjustment to account for regression-to-the-mean effects.

Cripps and Meyer (1994) investigated the heuristics and biases utilized in timing the replacement of durable products. They performed two experiments using MBA students as subjects. The replacement patterns of the subjects were compared with those that would have been predicted if subjects acted as rational economic agents, following the rules of optimal replacement theory. The results indicated that the subjects exhibited systematic departures from the optimal responses, i.e. biases, that were not reduced with experience. In general, subjects were biased toward under replacement. Subjects also exhibited a pronounced framing effect. This effect was explained by prospect theory (Kahneman and Tversky 1979). Prospect theory suggests that consumers adopt the level of utility they derive from their currently owned good as a point of reference and then adjust for gains and losses to determine the utility of various choices (Dher and Simonson 1992). In the Cripps and Meyer (1994) experiment, the opportunity to replace a current good with one that offers enhanced performance can be framed as a gain in utility. Whereas a motivation to replace caused by deterioration or obsolescence can be framed as an attempt to overt a loss. Prospect theory implies that the marginal (dis)utility for losses tends to be greater than the
marginal utility for gains of equal monetary amount. Therefore according to prospect theory, the ratio of replacement for deteriorating goods should be greater than that for improving goods. Purchase motivation (e.g., enhancement or deterioration) which holds no normative relevance, was found to significantly effect replacement behavior, thus providing evidence of a framing effect.

Mowen and Mowen (1986) conducted a series of three experiments to determine if biases which had been demonstrated in a consumer purchase context would also occur in a business setting. The first two studies indicated that business students exhibited the same framing effects demonstrated in Kahneman and Tversky’s (1981) research when the tasks had been recast into a business setting. The third experiment used both students and business managers as subjects. The results indicated that the experienced business managers exhibited the same patterns of decision bias as the student subjects.

Other studies have confirmed the existence of the cognitive bias known as base-rate neglect in business and professional decision making. Joyce and Biddle (1981) studied the problem of base-rate neglect among auditors. In many audit situations, auditors obtain an item of information and must alter their opinions concerning the probability of two or more competing hypotheses. For example, if the collectability of a large post-due
receivable is at issue, the report of a reliable, independent credit agency claiming that the customer is solvent but occasionally slow-paying will probably cause the auditor's opinion concerning the probability of collection to change (Joyce and Biddle 1981). The normative direction and amount of change can be calculated using Baye's theorem. However, Kahneman and Tversky (1972 451) found that "in his evaluation of evidence, man ... is not Bayesian at all." The primary purpose of the Joyce and Biddle (1981) paper was to test for the use of the representativeness heuristic by auditors in situations which could lead to systematic violations of Baye's rule, such as base-rate neglect. They performed a series of experiments with auditors from a major accounting firm as subjects. The subjects were given individuating information representative of a potential outcome as well as base-rate information on the rate of occurrence of that outcome. They were then asked to rate the probability of that event. In four of the five experiments, the auditor's probability estimates were regressed toward the base rate; but in all experiments, the average magnitude of the change was insufficient, indicating base-rate neglect. Performance was worst in situations where the base rate was low. This finding has practical significance because auditors often make judgments concerning the likelihood of low base rate, but highly
consequential events, such as the existence of fraud (Joyce and Biddle 1981).

More evidence of base-rate neglect in professional decision making was presented by Eddy (1986). He studied the probabilistic reasoning of medical doctors in the domain of breast cancer diagnosis and treatment. He cites a previous study (Casscells, Schoenberger and Grayboys 1978), and a convenience sample of physicians to determine that approximately 95% of physicians misinterpret probability statements about the accuracy of mammograms in the prediction of breast cancer. For example, in a case study of published articles, he reports one in which the physician overestimated the number of false positives by a factor of about 150 due to base-rate neglect. Eddy (1986) concludes that improvements in probabilistic reasoning, including debiasing, offer great opportunities for improving the quality and effectiveness of medical care.

The anchoring-and-adjustment heuristic and the related bias of insufficient adjustment was studied by Yudav (1994) in the marketing domain. Yudav investigated the manner in which buyers evaluate product bundles, two or more items grouped together with a common selling strategy. Results of two laboratory experiments indicate that consumers used an anchoring-and-adjustment heuristic. When all of the items in the bundle were presented simultaneously, subjects examined the items in decreasing order of perceived
importance, anchoring on the most important item and making insufficient upward or downward adjustments to form the bundle evaluation (Yudav 1994). A second experiment demonstrated that the biasing effects could be manipulated by changing the order of presentation. For example, consider the bundle consisting of an excellent computer, a moderate printer and a poor printer stand. Given a sequential presentation, the subject's initial evaluation could vary considerably, from excellent to poor, depending on which item was presented first. Because of the insufficient adjustment bias, the initial evaluation tended to dominate the overall evaluation. Examining the excellent item first resulted in a higher overall evaluation. Examining it later resulted in a lower overall evaluation, demonstrating the ability to influence biases through changes in the temporal order of item presentation, a component of presentation format.

Mowen and Gaeth (1992) also investigated the use of heuristics in the marketing domain. They reviewed the marketing and behavioral decision making literature to identify factors which contribute to errors in marketing decision making. They focused on the evaluation process during which available alternatives are compared. According to Mowen and Gaeth (1992) the process requires managers to assess probabilities and uncertain quantities. It is precisely this type of judgment problem for which Tversky
and Kahnemann (1974) have identified a plethora of heuristics and biases. Mowen and Gaeth found evidence in the literature that the judgment of marketing managers during the evaluation process may be systematically biased through the application of heuristics. The heuristics identified by Mowen and Gaeth (1992) as affecting marketing managers included the three major heuristics described by Tversky and Kahneman (1974) representativeness, availability, and anchoring-and-adjustment. Also included is a heuristic called subjective evaluation, which is related to prospect theory (Kahneman and Tversky 1979). In order to correct for the negative impact of the biases, Mowen and Gaeth recommend a number of debiasing techniques including training to understand the causes of bias, using formal methods such as decision trees, providing process feedback through the use of simulations, and developing worst case scenarios. Included among their specific examples are two instances of deliberately altering problem presentation to counter the effect of known biases. The first example consisted of deliberately suggesting extreme estimates in order to counter the insufficient adjustment bias related to the anchoring-and-adjustment heuristic. The second suggestion was to moderate the framing effect associated with sunk costs by making the sunk costs highly salient through cost/benefit charts (Mowen and Gaeth 1992). While Mowen and Gaeth (1992) suggest several methods of
debiasing, they note the paucity of quality research on 
debiasing and suggest that it represents an excellent 
opportunity for future empirical work.

Debiasing

As more has become known of cognitive biases in 
decision making, researchers have searched for methods of 
reducing those biases. This process is known as debiasing. 
Several strategies have been investigated with mixed 
results. Fischhoff (1982) suggests that debiasing 
strategies can be classified according to whether they 
assume fault for the bias lies with the judge, the task, or 
a mismatch between the judge and task. Biases due to faulty 
tasks are usually associated with poor research designs and 
can usually be reduced through clarification and motivation. 
Biases attributed to faulty judges have been the focus of 
several debiasing strategies. These strategies include 1) 
warning about the possibility of bias, 2) describing the 
extent and direction of the bias that is typically observed, 
3) providing feedback, and 4) offering an intense program of 
training and feedback (Fischhoff 1982). According to 
Fischhoff, strategies 2, 3, and 4 can be effective, but 
strategy 1, a simple warning to be careful about a 
particular bias, has been shown to be ineffective. The 
results of a study by Lopes (1987) provide evidence that 
simple warnings do little to reduce bias.
Several strategies have been suggested for reducing biases attributed to a mismatch between the judge and the task. These approaches are based on the concept that the proper unit for observation is the person-task system, and that success lies in making them as compatible as possible. Fischhoff (1982, 427) refers to those strategies as "cognitive engineering." They tend to be task specific, but effective strategies include: 1) forcing respondents to express knowledge explicitly, 2) encouraging subjects to search for negative information and not just collect information which supports their favored position, 3) decomposing the problem into smaller more tractable problems, and 4) proposing alternative formulations of the presented problem.

Cleaves (1987) discusses several biases and corrective techniques and their implication for the development of knowledge-based systems. In addition to the behavioral techniques of training and feedback, Cleaves recommends the mechanical techniques of using visual props to improve the elicitation of probability judgments. These props allow the individual to compare visual patterns rather than verbal or numeric expressions when making probability judgments.

**Graphic Displays**

Although DeSanctis (1984) states that "no firm conclusions can be made regarding the appropriateness of one

Effects of Presentation Format on Decision Making

尽管没有IS研究直接探讨表现格式对偏差和启发式的影响，但有几项研究在更广泛的意义上探讨了图形显示之间的关系，以及决定过程中表现格式的影响。
decision making. DeSanctis (1984) and Hwang and Wu (1990) provide reviews of many of these studies. The most consistent finding revealed in these literature reviews suggests that the efficacy of graphs as decision aids is dependent on the task characteristics and to a lesser degree, on the characteristics of the users (Dickson, DeSanctis and McBride 1986).

Vessey (1991) proposed the theory of cognitive fit to explain the interaction between the characteristics of the graph, task, and individual and their effect on decision making performance. Cognitive fit theory, which will be discussed more fully in Chapter III, describes the importance of creating a match between the problem representation, the characteristics of the task, and the problem solving skills of the user. Such a match results in a mental representation, (i.e., mental model), which best supports the strategies (or processes) required to perform the task and thus leads to optimal decision performance. Empirical support for cognitive fit theory has been provided by Vessey and Galletta (1991) and Umanath and Vessey (1994). Both of these studies classified tasks as either spatial or symbolic. The results of the studies demonstrated that supporting spatial tasks with graphs and symbolic tasks with tables results in improved performance, as predicted by the cognitive fit model.
Another important finding concerning the impact of graphs on decision making is the capacity of presentation formats to alter not only decision outcomes but also the decision-making process. Early studies of consumer behavior showed that changing information presentation formats influenced decision strategies (Bettman and Kakkar 1977). Johnson, Payne and Bettman (1988) suggest that since different displays formats affect the effort required for various decision strategies, decision makers may react to changes in display format by adopting strategies which minimize their cognitive effort. Jarvenpaa (1989) performed a study of the effects of task demands and graphical formats on decision strategies based on the concept of contingent decision behavior. Her results support the proposition that information presentation format influences decision time and the selection of acquisition and evaluation strategies by influencing the cognitive costs and benefits of the task environment. Todd and Benbasat (1991) demonstrated that graphic representation influences cognitive effort which in turn affects the selection of formal decision strategies. They found that decision makers are more likely to transform strategies to make it easier to work with specific information displays than to transform the information to fit a normative strategy (Todd and Benbasat 1991). One method of reducing cognitive effort is to use heuristics (informal decision strategies or rules of thumb) instead of
normative decision strategies (Johnson and Payne 1985; Bettman, Johnson, and Payne 1990). Tversky and Kahneman (1973) showed that by emphasizing different aspects of the display used to formulate a problem, one can control the choice of the heuristic that people use to solve that problem.

**Visual Salience**

The visual salience effect is one means by which changes in graphical displays can alter decision making. Visual salience refers to the differential or relative attention given to an elements in the visual field (Taylor and Thompson 1982). Visual salience is determined by variations in size, shape, or color. Graphic displays allow a great range of variation in the size and shape of their components relative to alphanumeric displays. The visual salience of items in a graphic display has been shown to influence both the order of acquisition and the perceived importance of information (MacGregor and Slovic 1986; Jarvenpaa 1990).

One possible mechanism underlying the salience effect is guided search (Wolfe et al. 1989). Guided search is a two-step process of acquiring information from a visual display. The first step is a fast, pre-attentive, parallel process which evaluates all items in the visual field and then guides the second stage, which is a slower serial
process. Visually salient items tend to stand out during stage one processing, tend to be processed first, and given relatively more attention during stage two (Hoffman 1978; Taylor and Thompson 1982).

The salience effect occurs when one's attention is differentially directed to one portion of the environment rather than to others, and the information contained in that portion receives disproportionate weighting in subsequent judgments (Taylor and Thompson 1982; Kisielius and Sternthal 1986). Taylor and Thompson (1982 156) suggest that it is "ease of recall, i.e., availability, that is the rout by which vivid information affects judgments" (parenthetical added). This argument supposes that vivid material has the advantage of being retrieved faster and easier than relatively less vivid material and thus has a greater effect on judgments because of its greater availability when judgments are made. Nisbett and Ross (1980) point out that visually salient information has more impact on judgments, i.e., is weighted more heavily, than less vivid information even if that information has "substantially greater probative and evidentiary value" (p. 44) because the information with the greater salience is more available in memory.

Pryor and Kriss (1977) performed two laboratory experiments to investigate whether the salience effect was mediated by the relative availability of the salient
element. The experiments utilized manipulations in language and word order to alter the salience of persons or objects in a written paragraph. The first experiment investigated the link between salience and availability. The results indicated a main effect between salience and availability. The second study focused on the relationship between salience and causal attribution. Again salience was manipulated through language and word order. After viewing the treatments, subjects were asked to what extent the relationship described in the paragraph was caused by the person and to what extent it was caused by the object. The results indicated a main effect for salience. The more salient the item, the greater was its causal attribution. Pryor and Kriss (1977, 53) concluded that "the salience of an element affects its availability in memory, which in turn mediated the causal attributions made to that element."

Kisielius and Sternthal (1986) conducted a literature review of empirical studies related to vividness effects and concluded that increased availability is one of the primary means by which vivid information affects judgment. However, this conclusion is not universally accepted.

Schedler and Manis (1986) tested the relationship between vividness, memory, and judgment in a laboratory experiment. They used language manipulation in a mock trial setting to manipulate the salience of items of evidence. While they found that increased salience resulted in
significantly higher scores for both recall and judgment, a causal model indicated that these effects were independent and that recall (a surrogate for availability) does not mediate the effect of salience on judgment. It should be noted that the experimental stimulus for this experiment was aural and utilized tape recorded voices instead of the visual stimuli of written text used by Pryor and Kriss (1977).

This current study seeks to determine whether relationships between salience, availability, and judgment reported in previous studies could be supported in a situation in which the visual salience of items was manipulated through the use of graphic representations.

**Visual Recency**

Salience is not the only characteristic of a visual display known to affect cognitive processes. Visual recency can also impact the way in which people process information. Christie and Phillips (1979) conducted a series of three experiments examining the effects of visual recency on recall and recognition. The results from the first two experiments indicated that the final item in a series of visual stimuli is easiest to recall or recognize after a short retention period. However, the results of the third experiment suggested that the recency effect could be
eliminated by imposing an intervening task between the visual stimulus and the response.

Walker and Marshall (1982) propose an explanation of Christie and Phillips’ results. They write: "subjects actively visualize the most recent item and that for as long as they are not distracted from this activity, detailed visual information regarding that final item continues to be readily available" (Walker and Marshall 1982 348).

Findings of recency effects on recall have not been uniformly supported. Unamath, Scamell and Dass (1990) purported to provide evidence against a recency effect on recall. However, their operationalization of recency consisted of placing items at the top, middle, or bottom of a video screen. Clearly the recency construct refers to temporal order and not spatial order as employed (Henson 1994).

Recency has been shown to affect not only recall, but also impression formation, or judgment. Dreben, Fiske and Hastie (1979) investigated the effects of serial presentation on both recall and judgment under a variety of different task conditions. The task condition entitled "continuous responding" most closely paralleled decision making based on computer displayed information. This task did not include an interim task between presentation of the final item in the series and the request for a final response. The rating scale used to record the response was
printed on the same page with the final stimulus. This is similar to a situation in which a decision maker has immediate access to computer generated information, either printed or online, while making a judgment. Under these conditions large recency effects were obtained. Dreben et al. concluded that under these conditions recency affects judgment by making the final item of information more available in the visual (attentional) field.

**Availability**

Although the visual salience effect and the visual recency effect are caused by different manipulations of the visual stimuli, they can both be linked to changes in decision-making behavior through the availability heuristic. An availability bias is said to exist when the information most easily brought to mind is influenced by possibly irrelevant factors such as recency and salience (Curt and Zechmeister 1984; Taylor and Thompson 1982). For purposes of this study, availability is defined as the cognitive effort associated with the perception, integration, construction, or recall of an item. Those items with the greatest availability require the least cognitive effort for inclusion in the decision process. A person is said to use the availability heuristic whenever he estimates frequency or probability by assessing the ease with which the relevant
mental operations of recall, construction, or association are performed (Tversky and Kahneman 1973).

Tversky and Kahneman (1973) report the results of eight experiments into the nature of the availability heuristic. Two of these demonstrated results which are relevant to the current study. Study #7 investigated the impact of changes in problem formulation on the subjects' choice of heuristics. Two different presentation formats were used, a graphic format in which individual examples of possible outcomes were made salient, and a written, textual format which emphasized the generic features of the problem. Subjects were asked to estimate the relative proportions of all possible outcomes of the problem. The results indicated that subjects used the availability heuristic when individual instances were emphasized and the representativeness heuristic when the generic features were made salient. Tversky and Kahneman concluded that the formulation of a problem controls the choice of heuristics that people adopt in intuitive estimation.

Study #8 investigated the relationship between availability, recall, and estimations of frequency. Subjects were presented one of two lists. One list consisted of the names of 19 famous men and 20 less well-known women. The other list contained the names of 20 famous women and 19 less famous men. Fame and frequency were inversely related on all lists. The first group of
subjects was asked to recall as many names as possible from the list. In this experiment, recall was used as a surrogate for availability. The results indicated that the more famous names were easier to recall, i.e., more available. The second group was asked to judge whether the list contained more names of women or of men. The results indicated that over 80% of the subjects erroneously judged the class consisting of the more famous names to be more frequent. Tversky and Kahneman concluded that subjects judged the frequency of the class (e.g., men or women) based on the ease with which examples could be recalled, i.e. availability.

While Tversky and Kahneman limited their discussion of the availability heuristic to judgments consisting of estimates of frequency and probability, other researchers have demonstrated that availability affects more general types of judgment. Taylor (1982) noted the use of the availability heuristic in social judgments. She proposed that highly salient data may be more available and thereby exert a disproportionate influence on the judgment process. She revealed that a person who is brightly lit, moving, dressed in a highly contrasting color, or novel in race or gender will be given a disproportionate amount of attention. Subjects in a series of experiments viewed one of two groups conducting an identical, scripted conversation. One member of the treatment group was made salient. The salience of
the individual affected judgment in several ways. The salient individuals' behavior was more easily recalled. They were judged to do more talking than the matching person in the control group. Moreover, salience resulted in more extreme evaluation of the persons behavior when compared to the same behavior in the control group. These findings support Taylor's contention that availability impacts social judgment.

Reyes, Thompson and Bower (1980) tested the hypothesis that information which is disproportionately available in memory will have a correspondingly disproportionate impact on evaluative judgments in a mock jury trial setting. Availability was varied by manipulating the vividness of evidence. The results support their conclusion that judgments can be biased by the availability of information.

Russo and Schoemaker (1992) investigated the relationship between availability and the use of decision aids in a business context. They report the results of a earlier experiment (Dube-Riox and Russo, 1988) in which actual managers in the hospitality industry were shown a fault tree diagram for restaurant failure analysis which identifies several potential problems that could result in declining profits. The potential problems listed in the fault tree were immediately available in the attentional field of the subjects. When originally asked what percentage of failures could be attributed to the listed
problems, the mean response was 93%. In reality, the problems listed in the fault tree accounted for only 54% of failures. The managers overestimated the importance of the more readily available information by 39%. A second group of managers was also given the fault tree, but they were asked to list other potential problems prior to estimating the percentage of failures caused by the problems on the original list. After the respondents had each added four new potential problems to the list, the overestimation of the importance of the original items dropped to just 12%. After they had added six new problems to the list, their overestimation of importance dropped to near zero. The importance of items was overestimated when they were made more available through inclusion in a decision aid. However, as additional items were made more available, the perceived importance of the original items was reduced. These findings suggest that one mechanism by which availability may impact judgment is by altering the perceived importance of items of information.

Recall

Recall has been used as a surrogate for availability (Tversky and Kahneman 1973). The task of recall must be differentiated from that of recognition. Both involve placing information in memory for later retrieval. In a recall task, subjects are required to reproduce the items in
response to a cue without being provided alternatives. In a recognition task, subjects are presented with a series of test items and must judge for each item whether it was presented during the information acquisition period, i.e., a multiple choice test (Posner 1989). The key difference between recall and recognition is in the structure of the retrieval cue. In recall, subjects are given the context and asked to reproduce the item. In recognition, they are given the item and asked to remember the context (Glass and Holyoak 1986).

The relationship between presentation formats and recall has received limited attention in the information systems literature (Henson 1994). In an early study Washburn (1927) presented information in a variety of formats including narrative, tables, bar graphs, line graphs and pictograms. The subjects for the experiment were 200 junior high school students who were required to answer questions based on information contained in the various presentations. Washburn's conclusion, based on a simple comparison of percentages, was that the task and presentation format interact to affect recall performance. For example, line graphs improved recall when the task required the identification of trends. In contrast, tables improved recall when the subjects were asked about specific amounts. These findings were supported by later research
and are consistent with the theory of cognitive fit (Vessey and Galletta 1991; Unamath 1994; Unamath and Vessey 1994).

In a study which utilized computer generated three-dimensional graphics, Watson and Driver (1983) examined the impacts of those graphs along with tabular presentations on both immediate and delayed recall. They reported no significant difference in recall performance across presentation formats. There are several alternative plausible explanations for the lack of significant difference. Small sample size is one factor which must be considered. The delayed recall experiment used only twenty-five subjects, fourteen for the graphics treatment group and eleven for the tabular treatment group. Watson and Driver suggested that the nature of the task might interact with the presentation format. It should also be noted that the task was not strictly one of recall. Subjects were shown physicians placement data covering a period of six years for each of the fifty states. They were given only one minute to study the material. They were then given a list of six states and were asked to rank order them by the number of physicians placed in each state. Subjects were not asked to recreate the information as is implied by the term recall. Another potential problem with this study was the choice of a three-dimensional graphic which depicted a map of the United States. Tufte (1983) warns against using more dimensions or complexity in a graph than is necessary.
Given that neither cardinal directions nor the physical distribution of physicians was required for the task, but only the names of the states and the number of physicians in each state, a two dimensional bar chart would have been more appropriate for this particular task. Another problem with the graph was that only nine of the states were labeled. Some top ranking states, such as Idaho, were not labeled while others not in the top ten were labelled. However, the most troubling shortcoming of the graphs used in this experiment was the lack of a vertical scale, which when combined with the unusual perspective used in the display, make the three-dimensional graph difficult to read. Considering the numerous flaws in the graphs used in this experiment, it is surprising that the subjects in the graphic treatment did not perform significantly worse than those in the tabular group.

Umanath performed a series of investigation into the impact of presentation formats on recall performance. Umanath and Scamell (1988) describe a recall experiment in which 108 practicing managers were used as subjects. The analysis of their results indicated that the effect of a graphical display on recall was task specific. Bar charts were shown to result in significantly increased recall performance when compared to tables for tasks which required pattern recall and the recall of directional order. When the task required the recall of a specific fact, there was
no significant difference between the two presentation formats.

Umanath (1994) described the results of two laboratory experiments to examine the interaction between presentation format (e.g., tabular/graphic), information load, information acquisition strategy (e.g., directed or incidental), and cognitive style. Directed information strategies are those used when the acquisition of information is for a particular purpose. Incidental strategies are used when information is acquired without having a specific preconceived use for it.

The results of the study indicated no significant main or interaction effects attributable to variations in cognitive style as measured by the VVQ. The results further indicated that when the information load is small, recall performance is unaffected by variation in information acquisition strategy. Umanath found that at increased levels of information load, the incidental acquisition strategy resulted in better recall performance than the directed strategy when using a tabular presentation mode. However, when graphs were used, subjects demonstrated no significant reduction in recall performance as information load increased. Moreover, the differences attributed to variation in acquisition strategy were not evident when using graphs. Umanath suggest that the aggregating property of graphs ameliorates the increased cognitive effort (see
Payne 1982 and Jarvenpaa 1989) associated with increased information load. Thus, in accordance with the cognitive cost/benefit principle, increases in information load will degrade recall performance at a slower rate for graphical presentation formats (Umanath 1994).

Individual Differences

A number of individual attributes are believed to impact the efficacy of computer-aided decision making. Zmud (1979) contends that the individual differences most relevant in an MIS context can be grouped into three classes: cognitive style, personality and demographic/situational variables. Modafsky and Kwon (1994) provide an extensive review of the relevant literature.

Several researchers have supported the proposition that cognitive style exerts an influence on decision making behavior (Zmud 1979; Henderson and Nutt 1981; Robey and Taggert 1982; Benbasat and Dexter 1982; Benbasat and Taylor 1982; Hunt et al. 1989). Cognitive style is a multi-dimensional construct (Zmud 1979). A few examples of dimensions of cognitive style that have been studied in MIS research include field dependence/independence (Benbasat and Dexter 1982), analytic/heuristic decision styles (Dickson, Senn and Chervany 1977; Lucas and Nielsen 1980), Jungian personality types, i.e. introvert/ extrovert, sensing/intuition, thinking/feeling (Blaylock and Rees
1984), and visual and verbal learning style preferences (Umanath and Scamell 1988). Robey and Taggert (1982) suggest that hemispheric lateralization can provide a unifying construct for relating the multiple dimensions of cognitive style.

DeSanctis (1984) noted the importance of individual differences, including hemispheric dominance, to the study of the effects of graphs on decision making. Visual or verbal orientation are purported to be indicators of cerebral dominance (Robey and Taggert 1982). Learning style, also known as sensory modality preference, describes a subject's preference for acquiring information from visual or verbal stimuli (Green and Schroeder 1990). Given the current study's use of treatments consisting of visual and verbal presentation formats, learning style preference, a sub-component of cognitive style, was determined to be a possible moderating factor on the influence of these alternative presentation formats on decision making behavior.

It must be noted, however, that the importance of cognitive style in relation to MIS design is not universally accepted. Huber (1983) notes the paucity of valid and reliable measures of cognitive style and the confusion caused by inconsistent definitions which often fail to differentiate between cognitive style and cognitive ability. In addition, he points out that the results of previous
studies regarding the effects of cognitive style are weak and inconclusive. Huber (1983) observes that even in studies which show significant results, cognitive style tends to account for a relatively small amount of the variance in the dependent variable. Moreover, both Huber (1983) and Robey (1983) agree that users may override their measured style preferences to adjust to the demands of the task.

Summary of Background Research

No prior research was identified in the IS literature specifically related to the effects of presentation formats on cognitive biases, therefore this review focused on the related areas of behavioral decision making, biases and heuristics, and the cognitive effects of various presentation formats.

Although the effects of presentation formats on biases and heuristics have not been studied specifically, much can be established from the existing literature. The ubiquitous nature of cognitive bias in business decision-making has been well documented. The root causes of cognitive biases have been explained. Several possible methods for moderating the impact of biases have been described. Research has shed light on a potential mechanism for influencing the decision process and an underlying theory has been identified which can be used to explain the
interactions between changes in presentation format and cognitive biases in decision making.

Several examples were cited illustrating the effects of cognitive biases on various business decisions including strategic planning (Barnes 1984; Schwenk 1988), retail buying and sales projections (Cox and Summers 1987), auditing (Joyce and Biddle 1981; Schwenk 1988), business failure analysis (Dube-Rioux and Russo 1988), the replacement of durable goods (Cripps and Meyer 1994), the evaluation of product bundles (Yadav 1994), the evaluation of marketing programs (Mowen and Gaeth 1992), corporate budget forecasting (Walker and McClelland 1991) and real estate pricing (Northcraft and Neal 1987).

Newell and Simon (1972) demonstrated that, due to limits in human information processing, human decision making is not entirely rational, especially under conditions of uncertainty. Under conditions of uncertainty, decision makers often rely on heuristics. The use of heuristics has been shown to result in predictable cognitive biases (Tversky and Kahneman 1974). These biases can occur when the decision maker assigns inappropriate relative decision weight to specific items of information (Arkes and Hammond 1986; Weber 1994).

Several debiasing techniques have been investigated in an attempt to reduce the effect of cognitive biases. One of the suggested debiasing techniques is problem reformulation
through changes in the visual presentation of information (Cleaves 1987). Both Jarvenpaa (1989; 1990) and Todd and Benabast (1991) demonstrated that changes in presentation format could alter the decision-making process. These researchers suggested that Payne's (1982) cognitive cost/benefit theory might be used to explain the impact of changes in presentation format. Changes in presentation format alter the decision-making process by changing the cognitive costs associated with various strategies (Todd and Benabasat 1991). The concept of cognitive cost is similar to the psychological construct known as availability. Availability has been defined as the cognitive effort associated with the perception, integration, construction, or recall of an item (Tversky and Kahneman, 1973). Those items with the greatest availability require the least cognitive effort for inclusion in the decision process. An availability bias exists when the information which can be most easily recalled and integrated into the decision-making process is influenced by possibly irrelevant factors such as recency and salience (Curt and Zechmeister 1984; Taylor and Thompson 1982). Information which is disproportionately available in memory has been demonstrated to have a correspondingly disproportionate impact on judgment (Reyes et al. 1980), and to result in an increase in the perceived importance of the available items (Dube-Rixo and Russo 1988).
A synthesis of the background literature suggests that an IS designer might purposefully create an availability bias by manipulating the salience or recency of items in a visual display. This could result in altering the applied decision weight, or subjective utilization, of specific items of information. Since biases can be attributed to an inappropriate assignment of decision weight to items during the decision process, this technique might be used to alter the effects of specific cognitive biases.
CHAPTER REFERENCES


Washburne, Jon N. "An Experimental Study of Various Graphic, Tabular and Textual Methods of Presenting Quantitative Material." The Journal of Educational Psychology 18.6 (September 1927): 361-376.


CHAPTER III

THEORETICAL FRAMEWORK AND HYPOTHESES

As demonstrated by the previous review, the cognitive processes which lead to biases and heuristics in decision making have been well researched and are supported by underlying psychological theory. Unfortunately, the same cannot be said for research into the cognitive effects of differing presentation modes. In order to purposefully moderate or influence the use of specific biases and heuristics through changes in presentation format, one must be able to predict, a priori, the impact of changes in presentation format on the cognitive processes underlying decision-making behavior. Theory-based explanations for how differing presentation modes affect the cognitive mechanisms used in decision making must be developed. This study focused on two effects which can be made manifest by altering presentation formats -- the visual salience effect and the visual recency effect.

Model Development

An availability model of the impact of presentation mode on heuristics and biases is illustrated by Figure 4. This model was derived from several earlier models and theoretical frameworks in the areas of decision making.
(Simon 1960; Arkes and Hammond 1986), biases and heuristics (Tversky and Kahneman 1974), and the study of graphs as decision aids (DeSanctis 1984; Jarvenpaa 1989; 1990; Vessey and Galletta 1991).

DeSanctis (1984) developed a framework for research on the use of graphics as decision aids (see Figure 5). This framework is based on variables used in previous research. According to this framework, graph characteristics such as the type of graph (e.g., bar, line, and pie chart) and its visual features (e.g., color, complexity, and labeling)
should be considered in conjunction with user characteristics and the decision-making environment in order to understand the effectiveness of graphics in support of decision making. DeSanctis (1984) states that the basic question regarding graph characteristics is how to design graphs that can be quickly read and accurately interpreted, i.e. graphs which foster quality decision making. According to DeSanctis (1984 481), the objective of such study is "to learn how to design displays that avoid poor information acquisition or cognitive bias on the part of the reader."

Figure 5. Framework for the Use of Graphics as Decision Aids
Source: DeSanctis (1984)
User characteristics hypothesized to play a role in the effect of graphics on decision making include experience with graphics, task knowledge, and personality variables. DeSanctis (1984) states that these variables likely interact with decision context variable to determine how information is obtained from graphical displays. The decision context variables include task complexity, task content, degree of structure and the quality of available decision alternatives -- all of which have been shown to affect decision making (Payne 1982). The decision context variables are represented in the availability model as Problem (Task) Characteristics (see Figure 4).

User characteristics are not included in the availability model. This does not imply that they are not important, they simply are not part of the focus of this research. Although not included in the model, the experiment was designed to control for differences in user characteristics. For example, the use of knowledge lean tasks reduces the impact of differences in task knowledge.

DeSanctis (1984) also postulates that cognitive variables interact with the characteristics of the graph, user, and decision context to influence the decision outcomes when graphics are used. Characteristics of the graph are included in the availability model as Problem Presentation (see Figure 4). DeSanctis mentions both cognitive process variables such as information processing
activities and decision strategy adopted, as well as cognitive style variables such as hemispheric dominance. Cognitive variables combined with the characteristics of the graph, user, and decision context influence the interpretation of the graph, which in turn influences the user's comprehension of the problem and the decision outcome. Outcome measures identified as worthy of consideration include both the speed and quality of decision making (DeSanctis 1984).

Cognitive process variables such as information processing activities and decision strategies (e.g., heuristics) are included in the availability model as Decision Strategy. A single cognitive style variable, learning style, is also included as a possible moderating variable during information acquisition (see Figure 4). The use of decision speed as a dependent variable is not considered relevant to the proposed research. However, decision quality is included by examining the impact of the cognitive biases on judgment.

Payne (1982) proposed a cost-benefit framework of cognition based on the concept that decision makers focus on the trade-off between cognitive effort and accuracy, i.e. decision quality. According to the cost-benefit framework, the decision maker combines the joint objectives of maximizing decision quality while minimizing cognitive effort (Johnson and Payne 1985; Bettman, Johnson and Payne
Jarvenpaa (1989) developed a theoretical framework based on this concept of contingent decision behavior. Her results suggest that the information presentation format influences decision time and the selection of acquisition and evaluation strategies by influencing the cognitive costs and benefits of the task environment.

Jarvenpaa (1990) developed a theoretical framework to study the impact of visual salience on decision making. She included in her framework a well-accepted model for information acquisition which asserts that information acquisition occurs in two stages, a pre-attentive, fast, parallel evaluation of the entire display (stage 1) which guides a slower serial stage (stage 2) (Hoffman 1978; Wolfe, Cave, and Fanzel 1989). It is during the early stages of information acquisition that changes in presentation mode impact the decision-making process (Einhorn and Hogarth, 1981; Jarvenpaa 1990). Jarvenpaa's (1990) framework stated that for a graphic display, the visual salience of items influences the initial stage of information acquisition. This in turn influences the attention and importance assigned to the item, and that the attention drawn to an item can influence judgment.

Jarvenpaa's hypothesized relationships between problem presentation, visual salience, two-stage information acquisition, and choice of decision strategy are all included in the availability model. The influence of
Jarvenpaa's framework on the availability model is represented by Information Acquisition (see Figure 4) and the arrows which show information acquisition being influenced by problem presentation and subsequently affecting the decision process.

Vessey and Galletta (1991) derived a paradigm of cognitive fit which they describe as a special case of Payne's (1982) cost/benefit principle. Their research indicates that matching the type of display to the task minimizes both effort and error. Figure 6 presents the model of problem solving on which the cognitive fit theory is based. Although many characteristics are related to cognitive fit, Vessey and Galletta view problem representation as the most important. According to their problem solving model, optimal problem solution is dependent on a match or "fit" between the problem solving task, the problem representation and the problem solving skill of the decision maker.

Cognitive fit is said to occur when the problem representation and the task both emphasize the same type of information. In the cognitive fit general model, information was divided into two broad categories—spatial and symbolic. This distinction is analogous to the difference between images and words described in the psychology literature by Pavio (1971) and in the graphics literature by Bertin (1981). According to this
classification, graphs are spatial problem representations and tables are symbolic problem representations. Tasks can also be divided between symbolic and spatial types. Spatial tasks, which are said to be facilitated by graphs, are tasks that require making associations or perceiving relationships in the data, rather than focusing on discrete values. In contrast, symbolic tasks involve extracting discrete and precise data values. Symbolic tasks are said to be facilitated by the use of tables. According to the cognitive fit model, optimal problem solving will result from a match between task type, representation and the problem solving skill of the user.

![Figure 6. Cognitive Fit - Problem Solving Model](Source: Vessey and Galletta (1991))
The availability model is largely consistent with the cognitive fit model proposed by Vessey and Galletta (1991). Both models are consistent with Payne's (1982) cost/benefit model. In addition, both models focus on the importance of problem representation in decision making. The impact of spatial/symbolic problem solving skill is related to the learning style portion of the availability model. Preferences for verbal or visual learning styles are likely to result from having discovered that one has superior verbal or spatial abilities (Richardson 1983).

The main difference between the two models is that the cognitive fit model focuses on matching the general type of the problem representation (e.g., graphical or tabular) with the general problem type (e.g., spatial or symbolic), whereas the availability model focuses on the representation of specific items of information in the display and the impact of those representations on specific heuristics and biases. Thus, while largely compatible with the cognitive fit model, the availability model describes the problem solving task at a lower level of abstraction. The influence of the cognitive fit model in the development of the availability model is demonstrated by the inclusion of the mental representation construct.

Todd and Benbasat (1991) also derived a theoretical framework based on the cognitive cost/benefit principle. They demonstrated that graphic representation influences
cognitive effort which in turn affects the selection of formal decision strategies; i.e. additive compensatory, additive difference, conjunctive model, and elimination by aspect; when solving multi-alternative, multi-attribute preferential choice problems.

The availability model is consistent with the general cognitive cost/benefit framework described by Payne (1982) and supported by Jarvenpaa (1989) and Vessey and Galletta (1991). The availability of an item as defined in this model is analogous to its cognitive cost or the cognitive effort required to use the item. Using the cognitive cost/benefit model, Todd and Benbasat (1991) concluded that by altering the cognitive effort required to use a specific component of a decision strategy, the strategy adopted by the decision maker can be influenced.

At the broadest level, this research deals with human decision making. Simon’s (1960) model of decision making divides the decision making process into three phases: intelligence, design, and choice. The intelligence phase deals with information acquisition. The design phase involves inventing, developing, and analyzing possible courses of action. The choice phase involves selecting an alternative or course of action from those available. The three phases of the Simon model are included in the availability model. The intelligence phase corresponds to information acquisition. The design phase is represented by
the decision strategy. This represents the portion of the decision process in which the decision maker selects, whether consciously or not, a decision strategy or heuristic as the method to be used to solve a particular problem. The choice phase of Simon's model is explicitly represented.

Arkes and Hammond (1986) developed a general model of judgment which is illustrated by Figure 7. Their model defines judgment as a cognitive or intellectual process in which a person makes an inference \( (Y_s) \) about an event \( (Y_e) \) which cannot be observed on the basis of data \( (X_i) \) which can be observed. "Judgements are made from tangible data which serve as cues to intangible events and circumstances" (Arkes and Hammond 1986, 7). This model can be used for a posteriori decomposition of a person's judgment. A person's judgment policy, which is similar to the concept of a mental model of the judgment task, can be inferred after judgments are made by analyzing the elements of the judgment model. The accuracy of judgments \( (r_a) \) represents the degree to which the judgment coincides with the actual event or circumstance to be judged. The model in Figure 7 introduces the concept of differential weight. According to Arkes and Hammond, individual cues may have differential weight, i.e., they are of differential value in making inferences about events. Cues with a strong relation or high degree of covariation with the event to be inferred have high ecological validity \( (R_{e,i}) \). Their weight is thus higher than
the weight for those cues with lower degrees of covariation.

Figure 7. General Judgment Model
Source: Arkes and Hammond (1986)

The psychological counterpart to the ecological validity of a cue ($X_i$) is its subjective utilization ($r_{s,i}$) by the subject. Cues are used or depended on to varying degrees. The impact of a cue on a person’s judgment is related to the subjective utilization of the cue. A researcher may compare the differential weights of a set of cues ($r_{s,i}$) with the weights implicitly assigned to the cues (e.g., their subjective utilization). Poor correlations between the ecological validity and the subjective
utilization of cues are a source of sub-optimal judgements. In other words "one source of poor judgment lies in the failure to attach the correct relative weights or importance to cues" (Arkes and Hammond 1986, 9).

Weber (1994) describes possible causes for mismatches between ecological validity and subjective utility under conditions of risky choice. One possible explanation for the distribution of attentional focus and thus assigned decision weight (e.g., subjective utilization) is the effect of information displays that redirect attention without changing the outcomes of possible answers (Weber 1994). It was hypothesized that people may give greater weight to those items that are more salient in the display. The concept of subjective utilization/decision weights is included in the availability model.

Perhaps the seminal article concerning heuristics and biases in decision making was written by Tversky and Kahneman (1974). They describe three heuristics which people use to reduce the complex tasks of assessing probabilities and predicting uncertain values into simpler judgmental operations. According to Tversky and Kahneman (1974), it is the use of heuristics that leads to systematic errors or biases in judgment. Payne, Bettman and Johnson (1992) expand on Tversky and Kahneman stating that uncertainty, limits to human cognition, or the lack of a formal decision strategy can all lead to a need to simplify
the decision process through the use of heuristics, and the use of these heuristics leads to predictable biases (see Figure 8). Many of the biases can be identified indirectly through the recognition of patterns of sub-optimal judgments. The relationships between heuristics, biases, and choice proposed by Tversky and Kahneman (1974) are represented in the availability model (see Figure 4).

Figure 8. Biases and Heuristics

Description of the Model

The availability model starts with problem or task characteristics. These include task complexity, task
content, degree of structure and the quality of available
decision alternatives (DeSanctis 1984).

Before the problem can be solved, it must be presented
to the decision maker. Variables associated with problem
presentation include format (e.g., graphs, tables, text
etc.); size; color; temporal order; and content, i.e. what
information is included in the display. Problem solvers
induce their mental representations from the problem
presentation (Perrig and Kintsch 1985).

Before a mental representation can be constructed, the
problem solver must internalize the information contained in
the problem presentation through the information acquisition
process. This study focuses on two cognitive effects which
can be created by manipulating presentation formats. The
visual salience effect and the visual recency effect.
Visual salience refers to the differential attention given
to elements in the visual display (Taylor and Thompson
1982). It is created by variation in size, shape or color.
The recency effect refers to the assignment of undue
importance to the last items in a sequential presentation
(Cleaves 1987). The availability model also recognizes the
two-stage model of information acquisition described by
Hoffman (1978) and Wolfe, Cave and Fanzel (1989). It is
theorized that visual salience impacts information
acquisition during the early pre-attentive phase-stage 1
(Jarvenpaa 1990). Given that the recency effect is
dependent on temporal order, it is theorized to impact information acquisition during the sequential attention phase-stage 2.

Learning style, or sensory modality preference, is a component of cognitive style and is proposed as a moderating variable on the impact of changes in presentation format during information acquisition (DeSanctis 1984). For example, the addition of a graphic to a visual display in order to increase the visual salience of an item is theorized to have a relatively greater impact on subjects with a visual learning style preference.

The availability model indicates that salience and recency impact the availability of items in the mental representation of the decision maker. Availability is defined as the ease with which an item of information is perceived, recalled, or integrated into the problem solution (Tversky and Kahneman 1973). Items with the highest availability require the least cognitive effort for inclusion in the decision process. Studies have shown that salience or vividness increases the availability of items (Taylor and Thompson 1982; Pryor and Kriss 1977; Shedler and Manis 1986; Kisielius and Sternthal 1986). The relationship between availability and recency is supported by Dreben, Fiske and Hastie (1979), Mackenzie 1986, and by Christie and Phillips (1979) who showed that the final item of a series of visual stimuli is more available for recall.
Increased availability of items will result in an increase in subjective utilization, also known as applied decision weight (Tversky and Kahneman 1973, Dube-Riox and Russo 1988; Weber 1994). Reyes et al. (1980) demonstrated that information which is disproportionately available in memory has a correspondingly disproportionate impact on subject’s judgment. In addition, the availability of items influences the use of specific decision strategies or heuristics (Jarvenpaa 1989; 1990; Todd and Benbasat 1991).

The use of heuristics is predicated by the combination of certain problem characteristics and limits to human information processing capabilities (Newell and Simon 1972). These characteristics include uncertainty, complexity and a lack of formal solution methods (Tversky and Kahneman 1974; Payne, Bettman and Johnson 1992). All of these characteristics were controlled in this study in order to induce the use of specific heuristics.

The use of heuristics leads to predictable biases (Tversky and Kahneman 1974). The biases under study (e.g., base-rate neglect, the framing effect and insufficient adjustment) can all be attributed to an inappropriate assignment of decision weight or importance to specific items of information. The weight or importance assigned to an item during the decision process is also known as the item’s subjective utilization (Arkes and Hammond 1986). As noted above, changes in item availability are theorized to
affect the subjective utilization of items. Thus changes in the availability of items will alter the impact of cognitive biases through changes in the subjective utilization of specific items of information.

A judgment or choice is the final output of the decision process. An a posteriori analysis of decision outputs can be used to infer the extent of cognitive bias in the decision process (Arkes and Hammond 1986). Therefore, the impact of any changes in presentation format which alter the effects of cognitive biases should be observable in the decision outputs.

In summary, prior research has demonstrated that changes in presentation format alter the visual salience and visual recency of items. Salience and recency effects can alter the availability of an item. The availability of items affects the subjective utilization, or decision weight, assigned to those items during the decision-making process. In this way, altering the availability of items can modify the impact of cognitive biases on the decision maker's final judgment.

Hypothesis

The base-rate fallacy, framing effect, and anchoring-and-adjustment biases are all caused by either over or under weighting the importance of items in the decision-making process. The background for the theoretical framework has
shown that salience and recency can affect the availability of items and that availability can influence the attention and weight assigned to items during decision making. Therefore, it should be possible to alter the effects of the base-rate fallacy, framing effect, and anchoring-and-adjustment bias by manipulating the salience or recency of items in a visual display. This amounts to creating an intentional availability bias in an attempt to influence the decision process. In theory, this procedure could be used to either moderate or exacerbate the effects of the cognitive biases under study.

Hypotheses H1 and H2 are designed to test assumptions in the availability model which have been supported by previous research. They are not the primary focus of the proposed research but may help to show a causal chain between changes in visual salience and subsequent changes in decision behavior.

H1 Visual salience has no impact on the recall of items.

H1a There is no difference in the proportion of subjects who accurately recall the base-rate between the GRAPHIC and NOGRAPHIC groups.

H2 Visual salience has no impact on the perceived importance of an item in a visual display.

H2a There is no difference in the mean perceived importance of the base-rate between the GRAPHIC and NOGRAPHIC groups.
H2b There is no difference in the rankings of the perceived importance of the base-rate between the GRAPHIC and NOGRAPHIC groups.

Hypothesis H3 deals with the relationship between visual salience of items in a visual display and the base-rate neglect bias. Base-rate neglect is caused by underweighting the importance of the base rate. According to the availability model, increasing the visual salience of an item will increase its availability. By increasing the visual salience of the base rate through the use of a graphic, it may be possible to purposefully induce an availability bias which will increase the impact of the base rate on the decision process and thereby reduce base-rate neglect.

H3 Visual salience has no impact on base-rate neglect.

H3a There is no difference between the mean estimates of proportion for the GRAPHIC and NOGRAPHIC groups.

H3b There are no differences in the mean estimates due to the interaction of graphic treatments and verbal and visual scores.

The purpose of hypothesis H4 is simply to determine if the task used in one of the experimental treatments will induce subjects to use the anchoring-and-adjustment heuristic. This will allow more accurate interpretation of results found while testing hypotheses H5.
H4 The sales estimation task does not cause a majority of subjects to use the anchoring-and-adjustment heuristic.

Hypothesis H5 explores the relationship between visual recency and the adjustments made by subjects using an anchoring-and-adjustment heuristic. According to the availability model, visual recency increases the availability of items. Therefore, it may be possible to alter the estimates of decision makers using anchoring-and-adjustment by presenting data items sequentially instead of simultaneously. The availability model implies that the decision makers choice of an anchor and subsequent direction and degree of adjustment should be more greatly influenced by that information which is received latest in temporal order.

H5 Visual recency has no impact on biases associated with the anchoring-and-adjustment heuristic.

H5a There is no difference between the mean estimates of sales for the GRAPHIC and NOGRAPHIC groups.

H5b There are no differences in the mean estimates of sales due to the interaction of graphic treatments and verbal and visual scores.

Hypothesis H6 deals with the relationship between visual salience and the framing effect. The framing effect can be attributed to over weighting the importance of the frame during the decision process. According to the
availability model, it may be possible to increase the availability of the underlying probabilities in a choice under risky conditions by increasing the visual salience of those probabilities. This may tend to increase the relative importance of the probabilities and decrease the relative importance of the frame during the decision process. Thus, it may be possible to alter the framing effect by purposefully inducing an availability bias.

H6 Visual Salience has no impact on the framing effect.

H6a There is no difference in the framing effect between the GRAPHIC and NOGRAPHIC groups based on the proportion taking the trade.

H6b There is no difference in the framing effect between the GRAPHIC and NOGRAPHIC groups based on the perceived quality of the trade.

This chapter developed the theoretical framework used in this research study. An availability model was described which was based on previous research in the areas of decision making, cognitive psychology, and graphical displays. Hypotheses were developed and discussed in relationship to the availability model.
CHAPTER REFERENCES


CHAPTER IV

RESEARCH DESIGN

General

A laboratory experiment was used to study the effects of presentation mode on biases and heuristics in human decision making. The experiment was divided into two phases. Phase I tested hypotheses based on decision outcomes. Phase II focused on validating those portions of the theoretical model related to the cognitive effects of the experimental treatments.

Phase I was divided into three parts. Each part utilized a separate task and was used to investigate the impact of alternative presentation formats on a specific cognitive bias. The specific biases and heuristics under study by each part were: phase I.A—base-rate neglect; phase I.B—the framing effect; phase I.C—the anchoring-and-adjustment heuristic. The objective of the study was to determine (1) if alternative presentation modes influence the use of the above listed biases and heuristics and (2) the influence of visual and verbal learning style, separately and in conjunction with alternative presentation modes, on the use of cognitive heuristics and biases.
Phase II was also divided into three parts. Each part examined a specific assumption concerning the cognitive impact of the visual stimuli used in phase I. Phase II.A examined the relationship, if any, between visual salience and the perceived importance of items in the visual display. Phase II.B tested the assumption that the task used in the anchoring-and-adjustment experiment results in the majority of subjects adopting the anchoring-and-adjustment heuristic strategy. Phase II.C examined the link between visual salience and recall, a surrogate for availability. The experimental designs associated with each portion of the experiment will be described separately. The relationship between the substantive hypotheses and different parts of the experiment is summarized in Table 1.

Designing the final experiment required two pilot studies. Improvements to instructions, procedures, questions and formats were made in each iteration. The first iteration consisted of a pilot study using 109 undergraduate students (Van Dyke 1994). This pilot study utilized unmodified questions taken directly from previously published research concerning heuristics and cognitive biases. The initial iteration utilized a hardcopy, paper format as a surrogate for a CRT display. The pretest subjects provided feedback for improvements to the experiment.
Table 1. Hypothesis and related portions of the experiment.

<table>
<thead>
<tr>
<th><strong>Hypothesis</strong></th>
<th><strong>Experiment</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>H1 Visual salience has no impact on the recall of items.</td>
<td>Phase II.C</td>
</tr>
<tr>
<td>H2 Visual salience has no impact on the perceived importance of an item in a visual display.</td>
<td>Phase II.A</td>
</tr>
<tr>
<td>H3 Visual salience has no impact on base-rate neglect.</td>
<td>Phase I.A</td>
</tr>
<tr>
<td>H4 The sales estimation task does not cause a majority of subjects to use the anchoring-and-adjustment heuristic.</td>
<td>Phase II.B</td>
</tr>
<tr>
<td>H5 Visual recency has no impact on biases associated with the anchoring-and-adjustment heuristic.</td>
<td>Phase I.C</td>
</tr>
<tr>
<td>H6 Visual salience has no impact on the framing effect.</td>
<td>Phase I.B</td>
</tr>
</tbody>
</table>

The second pilot study utilized 32 undergraduate students and was used to test new experimental questions which had been modified to be more relevant in a business context. In addition, this group provided feedback concerning the format of the answer sheets and the time required for each part of the experiment.

**Subjects**

The target population for this experiment was computer users who make business decisions. The subjects were undergraduate and graduate college students currently
enrolled in undergraduate classes in the College of Business Administration at the University of North Texas. The study utilized a self-selecting convenience sample. Students were motivated to volunteer by an offer of $5.00 for participation and the promise of awards totalling $150.00 to the subjects with the most accurate answer to one of the experimental questions. One hundred and eighty-seven of the subjects also received course credit for their participation. The amount of credit was at the discretion of individual instructors. Student volunteers were randomly assigned to treatment and control groups. Only one group of subjects was used. Each subject performed all six parts of the experiment. A total of 211 subjects participated in the experiment.

Measures

The Verbalizer-Visualizer Questionnaire (VVQ) is a simple paper and pencil test of learning style, also known as sensory modality style -- one of the proposed dimensions of cognitive style (Green and Schroeder 1990). The VVQ was developed by Richardson (1977) to classify individuals by their preferred means of processing information, or imagery preference. It is not a test of verbal or spatial ability; however, a preference for verbal or visual presentation modes may be affected by the subject's respective
performance (Richardson 1977). This relationship is discussed by Richardson as follows:

A preference for a verbalizing style is a preference for linguistic encoding (labeling or naming).... A preference for a visualizing style is a preference for literal encoding, i.e. the spatial layout of physical features, and attention to the sensory properties of the stimuli (e.g., color). The conscious accompaniment of thought for the verbalizer is the experience of inner speech; for the visualizer, it is the experience of inner pictures....

To have a strong preference for one or another style can have no more than an indirect association with its counterpart in the ability domain. As a result, it is likely, but not necessary, that a preference for the verbalizer style will emerge on the basis of having learned that one has a greater ability to perform well on verbal tasks. Similarly, a preference for the visualizing style is likely to result from having discovered that one has superior spatial abilities. (Richardson 1983, 12)

The current study utilized a modified version of the VVQ (see Appendix A) developed by Kirby, Moore and Schofield (1988). This version contains three separate scales: visual, verbal, and dream vividness. The dream vividness scale was found to be independent from the learning style domain (Kirby et al. 1988). Accordingly, only the verbal and visual scales were used. Factor analysis indicates that the verbal and visual scales of the VVQ must be considered independent dimensions and not endpoints of a bi-polar scale (McGrath et al. 1989). Therefore, the verbal and visual scales were scored independently. Subjects were divided into dichotomous groups, HIGHER or LOWER, for both verbal and visual learning style. Cutoff points were based on the mean scores for all subjects. The VVQ has been reported to
have adequate test-retest reliability with coefficients ranging from .48 to .91 (Green and Shroeder 1990). The alpha coefficients for the verbal and visual scales were .70 and .59, respectively (Kirby et al. 1988). Several demographic questions were added to the form containing the VVQ. The demographics collected included gender, age, class status, academic major, and employment information.

A decision strategy questionnaire was also developed for this study (see Appendix B). This instrument was developed specifically for this study and identified the decision strategies used by subjects when performing a sales estimation task. In order to develop the instrument, subjects in an instrument-development pilot study were asked to complete the experimental task used in phase I.C. After they had made their estimates, they were asked to record, in writing, the steps that they used to perform the task (see Appendix C). A group of thirty-two undergraduate student volunteers participated. The resulting written explanations were then analyzed separately by this researcher and an expert judge. Three different decision strategies were identified: random guessing in a range, anchoring-and adjustment, and the use of mathematical formulas. The majority of the respondents used a strategy consistent with the anchoring-and-adjustment heuristic. The different decision strategies elicited from the subjects were used to create a decision strategy questionnaire. This instrument
was used to determine the decision strategies utilized by subjects while performing the experimental task in phase I.C. The instrument is a multiple-choice, self-reported measure with an option provided for open-ended response for those subjects who's strategy does not match one of the three listed. The order of choices was randomized over four versions of the instrument to avoid ordering effects.

Treatments

The graphs and alphanumeric displays utilized in the experimental instrument were generated by a common business graphics application package (Freelance Graphics for Windows) on an IBM-compatible computer. Since color has been shown to affect cognitive processes independent of presentation format (Benbasat and Dexter 1985), only black-and-white graphs were used. The graphs were based on standards recommended by Tufte (1983), Jarett (1983), Andersen (1983) and Schutz (1961). Three types of graphs were used: pie charts, vertical bar charts, and pictographs. All of the charts followed basic principles suggested by Tufte (1983) and Jarett (1983). The first principle states that the representation of numbers should be directly proportional to the numerical quantities represented. The second principle states that clear, detailed, and thorough labeling should be used to prevent distortion and ambiguity. Tufte (1983, 93) stresses the importance of maximizing data-
ink, the ink arranged as a response to variation in the numbers represented, and minimizing "chart junk" - unnecessary content which does not add to the meaning of the chart. For this reason, he recommends varying shades of grey as opposed to ornamental hatching on charts. These guidelines were followed in developing charts for this study. Pie charts were used in phases I.A and I.B in order to show proportions and probabilities which must sum to one. Pictographs were used as an alternative to pie charts in order to show proportions in phase I.A. Vertical bar charts were used in phase I.C in order to illustrate sales data over time.

The tasks used in the experiments were adapted from questions used in prior research which demonstrated the ability of the tasks to induce the desired biases and heuristics in the subject's decision-making processes. The specific tasks will be detailed in later sections addressing each part of the experiment. Examples of the original questions and the modified versions are included in Appendix D.

Procedure

Subjects were allowed to sign-up for any one of eleven different administrations of the experiment. The sessions were held throughout one calendar week starting on Monday morning and continuing through Sunday evening. The use of eleven different administrations was necessitated by two
factors. The first factor was a limitation of access to only one room in an academic computing laboratory; thus limiting simultaneous access to only thirty computers. Another reason for the multiple sessions was to allow opportunities for students who were available at differing times to participate in the experiment. It was anticipated that offering times in the morning, afternoon, and evening on both weekdays and weekends would encourage the widest possible participation.

During each administration of the experiment, the researcher used a script containing all directions in order to minimize variation between different administrations. Subjects were randomly assigned to treatment and control groups. Seating during the experiment was carefully controlled in order to minimize the possibility of contamination caused by a member of one treatment group inadvertently observing the treatment display assigned to another group.

After a brief explanation of the experiment, all subjects read and signed an informed consent letter (see Appendix E). Next, each subject answered the demographic questions and the modified VVQ. All subjects received a short set of instructions and then completed the tasks contained in the on-line experimental modules. Fifteen minutes was allowed for completion of phase I. The three questions of phase I were randomized to avoid ordering
effects. All responses were recorded on separate answer sheets (see Appendix F). After subjects had completed phase I, they were given the answer sheets for phases II.A and II.B. This was done to preclude subjects from altering their answers to phase I after reading the questions in phase II. The subjects were allowed 10 minutes to complete phases II.A and II.B.

At this point subjects were required to wait so that all subjects would simultaneously start the treatment task of phase II.C, the recall task. The subjects were given two minutes to answer the experimental question and then told to remove the experimental disks from their machines and to reboot the computers. This effectively limited exposure to the phase II.C display to two minutes. Subjects were not told that they would later be required to recall the visual display. Subjects were then given twenty minutes to complete an intermediate task. The intermediate task required concentration on numeric displays, judgment and the recall of information unrelated to this experiment. Next, the subjects were asked to recall the original visual image used in the experimental treatment of phase II.C. The response mode called on subjects to recreate the image of the display to the best of their ability. They were encouraged to record anything that they could remember from the display. Five minutes was allowed for this phase of the experiment.
After all subjects had completed the experiment the answer sheets were collected and each subject received payment for their participation. Subjects were admonished before leaving not to reveal the nature of the experimental tasks to others. In order to test for any ordering effects across administrations, records were kept identifying the responses from each administration.

Phase I.A - Base-rate Neglect

The primary objective of this portion of the experiment was to test for the impact of presentation mode on a subject’s propensity to ignore base-rate information and to investigate the effects of learning style.

Experimental Design

The experiment was constructed as a 3 X 2 X 2 factorial design. The factors were presentation mode, visual learning style and verbal learning style. The presentation modes were PIE, PICTOGRAM and NOGRAPHIC. The learning style factor divided subjects into higher and lower visualizers (HIVIS, LOWVIS) and higher and lower verbalizers (HIVERB, LOWVERB) based on the sample means. The dependent variable was the subject’s estimation of probability. A summary of the variables used in phase I.A is presented in Table 2.
Table 2. Variable Analysis Table: Phase I.A

<table>
<thead>
<tr>
<th>Construct</th>
<th>Variable Type</th>
<th>Variable Name</th>
<th>Surrogate</th>
<th>Measurement</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual salience</td>
<td>Independent</td>
<td>Presentation format</td>
<td>Pie Chart</td>
<td>Controlled</td>
<td>Nominal 1-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pictogram</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No Graphic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive style</td>
<td>Moderating</td>
<td>Visual learning style preference</td>
<td>Relative score on VVQ scale</td>
<td>Visual scale of VVQ</td>
<td>Ordinal 1-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verbal learning style preference</td>
<td>Relative score on VVQ scale</td>
<td>Verbal scale of VVQ</td>
<td>Ordinal 1-2</td>
</tr>
<tr>
<td>Choice</td>
<td>Dependent</td>
<td>Estimate</td>
<td>Observed</td>
<td>Ratio</td>
<td></td>
</tr>
</tbody>
</table>

Task

The task question was derived from one used in a previous study on base-rate neglect by Bar-Hillel (1980). The original question was modified into a business problem. The original question and the modified version are presented in Appendix D.

Treatment

The GRAPHIC treatment consisted of the addition of a graphic to the display. Two types of graphs are used, a pie chart and a pictogram. In each case, the graphic shows the base-rate percentages in the total population.

The representativeness heuristic described by Tversky and Kahneman (1974) was used to predict base-rate neglect by the control (NO GRAPH) group. Since the problem scenario identifies a married person, the statistics dealing with married couples may appear to the decision maker as more
representative of the special case. The individuating information might appear to be more specific than the overall base rate, so the base rates may tend to be ignored.

The impact of the graphic treatment was predicted by the availability model. According to Jarvenpaa (1990), the visual salience of a portion of an information display can affect both the order in which information is acquired and the relative attention given to the information. In this case, the graph illustrating the base rates is easily distinguished from the accompanying alphanumeric information, lowering the cognitive effort required to acquire the data. This increases the availability of the item for inclusion in the decision-making process. This suggests that the subjects may increase the amount of importance or decision weight assigned to the base-rate information. Therefore, estimates of probability should be lower, i.e. closer to the base rate of 20%, for the subjects receiving the graphic treatment.

Data Analysis

Analysis utilized ANOVA to search for significant differences between groups. In addition, PIE and PICTOGRAM were combined and re-coded as GRAPHIC so that analysis could be performed comparing GRAPHIC and NOGRAPHIC treatments.
Phase I.B - Framing Effect

The primary objective of this portion of the experiment was to test for the impact of presentation mode on the framing effect.

Experimental Design

This portion of the experiment was constructed as a 2X2 factorial design. The factors were frame and presentation mode. Each factor had two levels. The frame level consisted of positive and negative framing. The presentation mode consisted of GRAPHIC and NOGRAPHIC. The treatment and control groups were randomly divided into two subsets and each group received either a positive (e.g., 20% chance of winning) or a negative (e.g., 80% chance of losing) frame for the question.

During the original pilot study (Van Dyke 1994), the response mode to this question was in nominal (e.g., Yes/No) form. This response mode limited statistical analysis to relatively weak tests of proportion. Stevens (1986 113-114) recommends the use of more than one dependent variable in this context, citing two reasons. First, any treatment is likely to affect the subject in more than one way. Second, the use of multiple measures will yield more detail during data analysis. Therefore, two response modes were utilized for this task. Each respondent was asked to rate the quality of a proposed investment. They were also asked whether they would make the investment. The dependent
variable was the difference in the framing effect between the GRAPHIC and NOGRAPHIC groups where the framing effect was defined as the magnitude of the difference in the ratings (or proportion of "yes" responses) between the positive and negative frames. A summary of the variables used in phase I.B is presented in Table 3.

Table 3. Variable Analysis Table: Phase I.B

<table>
<thead>
<tr>
<th>Construct</th>
<th>Variable Type</th>
<th>Variable Name</th>
<th>Surrogate</th>
<th>Measurement</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual salience</td>
<td>Independent</td>
<td>Presentation format</td>
<td>Pie chart</td>
<td>Controlled</td>
<td>Nominal 1-2</td>
</tr>
<tr>
<td>Cognitive frame</td>
<td>Independent</td>
<td>Frame</td>
<td>Positive or negative wording</td>
<td>Controlled</td>
<td>Nominal</td>
</tr>
<tr>
<td>Perceived quality</td>
<td>Dependent</td>
<td>Estimate</td>
<td>Observed</td>
<td>Ratio</td>
<td></td>
</tr>
<tr>
<td>Choice</td>
<td>Dependent</td>
<td>Estimate</td>
<td>Observed</td>
<td>Nominal yes/no</td>
<td></td>
</tr>
</tbody>
</table>

Task

The task consisted of two versions of a question from previous research by Levin et al. (1986) which has been shown to produce the framing effect. The original question has been modified into a business-orientated problem. The original question and the modified version are presented in Appendix D.

Treatment

The GRAPHIC treatment was the addition of a pie chart to the display. This chart showed the probabilities of both the positive and negative outcomes of each event.
The framing effect occurs when decision makers focus on the frame instead of the underlying probabilities of the problem. Two possible impacts from the addition of the graph to the display are consistent with the availability model and may predict the impact of the graph on the framing effect. First, the graphics size and shape differentiate it from the text; thus increasing the visual salience of the information contained in the graphs (e.g., the underlying probabilities). According to the availability model, this should cause the subjects to increase the weight assigned to the probabilities in the decision process, thereby reducing the relative importance of the frame. A second possible influence of the graphic treatment does not rely on the visual salience effect but is still consistent with the availability model. The original text display gives only one side of the probability information. The alternative probability must be inferred. For example, given that "the probability of winning is 20%," one must infer the 80% probability of losing. The addition of the pie chart makes the alternative probability explicit. This reduces the cognitive effort required to integrate the information, thus increasing its availability. According to the availability model, both of these possible impacts of the graphic treatment should result in a reduction of the framing effect as the relative importance of the underlying probabilities is increased relative to that of the frame.
Data Analysis

The data analysis consisted of both ANOVA and the Z-test of proportion to test for significant differences between the groups.

Phase I.C - Anchoring-and-adjustment Heuristic

The primary objective of this portion of the experiment was to test for impact of presentation mode on the anchoring-and-adjustment heuristic.

Experimental Design

The experiment was conducted using a 2 X 2 X 2 factorial design. The factors included presentation mode (1-PAGE, 2-PAGE), visual learning style (HIVIS, LOWVIS) and verbal learning style (HIVERB, LOWVERB). The dependent variable was the mean estimate of the next quarter's sales. A summary of the variables used in phase I.C is presented in Table 4.

Task

The sales projection task was adopted from Cox and Summers (1987). However, in the original experiment the researchers presented the data in a tabular format. The new version of this task is presented in Appendix D. Phase II.C of the experiment was designed to validate whether subjects use the anchoring-and-adjustment heuristic when completing this task.
<table>
<thead>
<tr>
<th>Construct</th>
<th>Variable Type</th>
<th>Variable Name</th>
<th>Surrogate</th>
<th>Measurement</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual recency</td>
<td>Independent</td>
<td>Presentation format</td>
<td>1 page vs. 2 page display</td>
<td>Controlled</td>
<td>Nominal 1-2</td>
</tr>
<tr>
<td>Cognitive style</td>
<td>Moderating</td>
<td>Visual learning style preference</td>
<td>Relative score on VVQ scale</td>
<td>Visual scale of VVQ</td>
<td>Ordinal 1-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verbal learning style preference</td>
<td>Relative score on VVQ scale</td>
<td>Verbal scale of VVQ</td>
<td>Ordinal 1-2</td>
</tr>
<tr>
<td>Choice</td>
<td>Dependent</td>
<td>Estimate</td>
<td>Observed</td>
<td>Ratio</td>
<td></td>
</tr>
</tbody>
</table>

**Treatment**

The treatment consisted of presenting fourteen quarters of sales data as either a one-page or two-page display. Both the 1-PAGE and 2-PAGE presentation modes contained the same fourteen quarters of historical data. No numbers were used on top of the bars in the bar chart presentation and no color was used. On the 1-PAGE presentation mode, all information is simultaneously available to the decision maker. In contrast, page 2 of the 2-PAGE presentation mode display shows the last four quarters of sales data. The most recent quarter's sales are intended as an obvious anchor for those subjects using the anchoring-and-adjustment heuristic.

The theoretical basis of the 1-PAGE versus 2-PAGE treatment rests on the availability bias by which more weight is given to information that is easy to recall (Kahneman and Tversky, 1974) and on the recency effect by
which more recently imparted information has more impact on
decision making (Taylor and Thompson, 1982). The
anticipated effect of the 2-PAGE treatment is for higher
estimates based on the assumption that the apparent trend
exhibited on the second page of the display, i.e. the most
recent information, will cause subjects to produce higher
estimates when compared to those subjects viewing the 1-PAGE
display.

Data Analysis

The analysis utilized two-way ANOVA to test for
significant differences between groups.

Phase II.A - Perceived Importance

The primary purpose of this phase of the experiment was
to examine the relationship between perceived importance and
the visual salience of items in the visual display.

Experimental Design

The experiment was constructed as a 3 X 2 X 2 factorial
design. The factors were presentation mode, visual learning
style and verbal learning style. The presentation modes are
PIE, PICTOGRAM, and NOGRAPHIC. The learning style factor
divides subjects into higher and lower visualizers (HIVIS,
LOWVIS) and higher and lower verbalizers (HIVERB, LOWVERB)
based on the sample mean. The use of multiple response
modes was deemed important in this experiment because there
are two different ways to define differences in perceived
importance; 1) a change in the absolute value of the perceived importance of an item and 2) a change in the relative perceived importance of the item as compared to other items of information in the display. Either of these could change without necessarily requiring a change in the other. Therefore, the dependent variables used in this experiment included both the subject's ranking and ratings of the perceived importance of items of information portrayed in the visual display. A summary of the variables used in phase II.A is presented in Table 5.

Table 5. Variable Analysis Table: Phase II.A

<table>
<thead>
<tr>
<th>Construct</th>
<th>Variable Type</th>
<th>Variable Name</th>
<th>Surrogate</th>
<th>Measurement</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual salience</td>
<td>Independent</td>
<td>Presentation format</td>
<td>Pie Chart</td>
<td>Controlled</td>
<td>Nominal 1-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pictogram</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No Graphic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive style</td>
<td>Moderating</td>
<td>Visual learning style preference</td>
<td>Relative score on VVQ scale</td>
<td>Visual scale of VVQ</td>
<td>Ordinal 1-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verbal learning style preference</td>
<td>Relative score on VVQ scale</td>
<td>Verbal scale of VVQ</td>
<td>Ordinal 1-2</td>
</tr>
<tr>
<td>Subjective utilization</td>
<td>Dependent</td>
<td>Importance rank</td>
<td>Perceived importance</td>
<td>Self report ranking</td>
<td>Ordinal 1-5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Importance rating</td>
<td>Perceived importance rating</td>
<td>Self report 7-point Likert scale</td>
<td>Interval 1-7</td>
</tr>
</tbody>
</table>

Task

This experiment used the same task as phase I.A, which has been adapted from Bar-Hillel (1980). Subjects were be
asked to rank a series of facts derived from the experimental stimulus. In addition, subjects were asked to rate the perceived importance of each item on a seven-point Likert-type scale.

**Treatment**

The GRAPHIC treatment consisted of the addition of a graphic to the display. Two types of graphs were used: a pie chart and a pictogram. In each case, the graphic showed the base-rate percentages in the total population.

**Data Analysis**

Data analysis included both the Mann-Whitney U test and ANOVA to determine if there were significant differences between the groups.

**Phase II.B - Decision Strategy**

The purpose of this portion of the study was to test the assumption that the task used in the anchoring-and-adjustment experiment (phase I.C) resulted in the majority of subjects adopting the anchoring-and-adjustment heuristic strategy.

**Experimental Design**

This portion of the study was non-experimental. It consisted simply of a survey question administered to subjects in order to discover the decision strategies used by the subjects when estimating quarterly sales based on information in a visual display. The value of interest was
the proportion of subjects who choose a strategy corresponding to the anchoring-and-adjustment heuristic. 

Task

Subjects used the decision strategy instrument developed for this experiment. Subjects viewed the experimental treatments used in phase I.C (see Appendix G). They were then asked to select the strategy from a list of three potential strategies which most closely described the decision strategy which they used to solve the problem. The instrument also allowed for an open-ended response for those subjects who could not find a match among the structured responses.

Treatment

The treatment consisted of presenting fourteen quarters of sales data as either a one-page or two-page display.

Data Analysis

Data analysis consisted of a one-tailed Z test of proportion in order to determine if more than fifty percent of the population used the anchoring-and-adjustment heuristic to solve the sales estimation task.

Phase II.C - Recall

The purpose of this portion of the study was to determine the relationship between visual salience and recall, a surrogate for availability.
Experimental Design

This experiment was constructed as an experimental group/control group, randomized subjects design (Kerlinger 1986 p.306). The dependent variable was the proportion of subjects in each group who correctly recalled the base-rate. A summary of the variables used in phase II.C is presented in Table 6.

Table 6. Variable Analysis Table: Phase II.C

<table>
<thead>
<tr>
<th>Construct</th>
<th>Variable Type</th>
<th>Variable Name</th>
<th>Surrogate</th>
<th>Measurement</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual salience</td>
<td>Independent</td>
<td>Presentation</td>
<td>Pie chart</td>
<td>Controlled</td>
<td>Nominal 1-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>format</td>
<td>No graphic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recall</td>
<td>Dependent</td>
<td>Estimate</td>
<td>Presence of</td>
<td>Observed</td>
<td>Nominal yes/no</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>base-rate in answer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Task

The task utilized in this experiment was based on Kahneman and Tversky (1973) (see Appendix D). It is similar to the task used in phase I.A on base-rate neglect. Subjects were given two minutes to answer the question associated with the display. They were then required to attend to an intermediate task for twenty minutes. After twenty minutes, the subjects were required to attempt a free recall of the information in the visual display. They were not prompted for any specific information, but only asked to recreate the visual display as closely as possible and to record any
items they could remember from the display. The only memory cue in the question was the title of the display.

**Treatment**

The experimental treatment consisted of the addition of a graphic to the display. The graphic depicted the underlying population base rates.

**Data Analysis**

Data analysis utilized the Z test of proportion to test for significant differences in the proportion of people who accurately recalled the base rate between the treatment and control groups.

**Basic Assumptions**

Task, treatment, learning style, and experimental conditions are explicitly controlled for in the study. The use of knowledge lean tasks is assumed to minimize any confounding factors related to individual differences in experience or education. It is assumed that the random assignment of subjects will control for extraneous variables and individual differences. All groups of subjects are thus assumed to be homogeneous due to randomization. The tasks involved in the study are assumed to be independent. Randomization of the order of questions during phase I and of responses on the answer sheets used in phase II are assumed to control for any ordering effects. It is further assumed that subjects were sufficiently motivated by the
combination of payment, course credit, and the chance of rewards that they would provide good faith efforts at solving the experimental tasks.
CHAPTER REFERENCES


CHAPTER V

DATA ANALYSIS

Data collected from the laboratory experiment were analyzed using Statistical Package for Social Sciences (SPSS-X). The alpha level selected for the rejection of the null hypothesis was 0.05. A total of 211 subjects participated in the experiment. Six responses were dropped from the experiment. Three could not be matched to VVQ scores, and three were not usable due to the large number of missing values. Thus, 205 usable responses were retained. The specific tests used, results, and discussion for each phase of the experiment are discussed separately.

Demographics

In addition to the data collected as a result of the subject's responses to experimental stimuli, demographic data on each subject was also collected. The descriptive statistics are summarized in Table 7. Age of participant (AGE) is a continuous variable representing the number of years. Months is a continuous variable representing the number of months that the respondent had worked in their current position.
Table 7. Demographics

**Age**
- Mean: 24.25
- Standard Deviation: 5.48
- Minimum: 18
- Maximum: 49

**Gender**
<table>
<thead>
<tr>
<th></th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>113</td>
<td>55.12</td>
</tr>
<tr>
<td>Female</td>
<td>92</td>
<td>44.88</td>
</tr>
</tbody>
</table>

**Classification**
<table>
<thead>
<tr>
<th></th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>10</td>
<td>4.88</td>
</tr>
<tr>
<td>Sophomore</td>
<td>21</td>
<td>10.24</td>
</tr>
<tr>
<td>Junior</td>
<td>52</td>
<td>25.37</td>
</tr>
<tr>
<td>Senior</td>
<td>110</td>
<td>53.66</td>
</tr>
<tr>
<td>Graduate</td>
<td>12</td>
<td>5.85</td>
</tr>
</tbody>
</table>

**Major**
<table>
<thead>
<tr>
<th></th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accounting</td>
<td>33</td>
<td>16.10</td>
</tr>
<tr>
<td>BCIS</td>
<td>78</td>
<td>38.05</td>
</tr>
<tr>
<td>Finance</td>
<td>17</td>
<td>8.29</td>
</tr>
<tr>
<td>Management</td>
<td>27</td>
<td>13.17</td>
</tr>
<tr>
<td>Marketing</td>
<td>31</td>
<td>15.12</td>
</tr>
<tr>
<td>Business</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undecided</td>
<td>7</td>
<td>3.41</td>
</tr>
<tr>
<td>Other</td>
<td>12</td>
<td>5.85</td>
</tr>
</tbody>
</table>

**Work Status**
<table>
<thead>
<tr>
<th></th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>66</td>
<td>32.67</td>
</tr>
<tr>
<td>Part Time</td>
<td>107</td>
<td>52.97</td>
</tr>
<tr>
<td>Full Time</td>
<td>29</td>
<td>14.36</td>
</tr>
</tbody>
</table>

**Months in Current Position**
- Mean: 16.77
- Standard Deviation: 29.38
- Minimum: 0
- Maximum: 180
The mean age of the sample was 24.25 years. The respondents were fairly evenly distributed between males (55.12%) and females (44.88%). A majority of the subjects were seniors (53.66%). Each major area of the college of business was represented. A large proportion of the respondents worked either part or full time (67.33%). The average time worked in a current position was 16.77 months.

Analysis of the demographic data indicates a subject pool that is older and possesses more job experience than might be assumed for a predominately undergraduate sample. These findings indicate a large number of non-traditional students, most of whom are currently employed. The large number of seniors indicates that many of the subjects were nearing completion of their undergraduate degrees. The subjects in this study represent a diverse cross-section of the college of business, including students majoring in accounting, business computer information systems, finance, management, and marketing. The target population for this study was computer users who make business decisions. The age, experience, and educational level of the subjects suggests that this sample is more representative of, and thus more generalizable to, the target population than might be expected in a typical convenience sample of undergraduate students.
Learning Style

Frequency distributions for the VISUAL and VERBAL scores of the VVQ are illustrated by Figure 9. Descriptive statistics for both scores are listed in Table 8: VVQ Descriptive Statistics.

Figure 9. VVQ-Frequency Distributions
Subjects were divided into groups of HIGHER and LOWER on each score, based on the sample means of 6.43 for the verbal scale and 8.82 for the visual scale. This resulted in the classification of 97 subjects as lower verbal (LOWVERB) and 108 higher verbal (HIVERB). The visual classification resulted in 65 lower visuals (LOWVIS) and 140 higher visuals (HIVIS).

Table 8. VVQ: Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Verbal</th>
<th>Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>6.43</td>
<td>8.82</td>
</tr>
<tr>
<td>StDev</td>
<td>1.97</td>
<td>1.44</td>
</tr>
<tr>
<td>Minimum</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Maximum</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

count (n) = 205

The sample means and standard deviations reported in Table 8 are very similar to those reported by Kirby et al. (1988) for college students over twenty years of age. Kirby et al. reported a mean verbal score of 6.33 with a standard deviation of 2.13, and a mean visual score of 8.20 with a standard deviation of 1.49.

Since each individual has two scores, the subjects can be grouped into four classifications based on their scores on both scales. Those groups are shown in Table 9-Learning Style: Combined Groups.
Table 9. Learning Style: Combined Groups

<table>
<thead>
<tr>
<th>Verbal</th>
<th>Visual</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Low</td>
<td>38</td>
<td>18.5</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>59</td>
<td>28.8</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>27</td>
<td>13.2</td>
</tr>
<tr>
<td>High</td>
<td>High</td>
<td>81</td>
<td>39.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>205</strong></td>
<td></td>
</tr>
</tbody>
</table>

Obviously, the visual and verbal scores are not evenly distributed. Subjects scoring high on both scales were the most numerous. Subjects scoring High on the verbal scale and low on the visual scale represented the smallest group.

Experimental Results

The results of each phase of the experiment are reported and discussed separately in the following sections. A summary of the results of hypothesis tests is presented at the end of the chapter.

Phase I.A - Base-Rate Neglect

This phase of the experiment tested hypothesis H3 which stated that visual salience has no impact on base-rate neglect. The subjects were divided into three treatment groups. Group one received a graphic treatment consisting of a pie chart (PIE). The treatment for group two utilized a pictogram (PICT). The third group received the no graphic treatment (NOGRAPH). Analysis of variance was used to test for significant differences between the groups as well as for interaction effects with visual and verbal learning style.
Results. ANOVA confirmed a statistically significant (p=.001) main effect for the graphic treatment groups (see Table 10). There were no statistically significant main or interaction effects with visual or verbal learning style. These results fail to reject the null hypothesis H3b (e.g., there are no differences in the mean estimates due to the interaction of graphic treatments and verbal and visual scores). The mean responses for the three treatment groups were: pie chart (PIE)- 49.47, pictogram (PICT)- 50.40 and no graphic (NOGRAPH)- 60.52. Since ANOVA indicated a significant main effect only for the graphic treatment groups and no interaction effects, single factor ANOVA was used to examine the differences between the treatment groups. The results indicate no significant difference (p=.819) between the two types of graphs (see Table 11). Given that there was no significant difference (p=.819) between the mean responses for the pie chart and pictogram groups, the two groups were combined and re-coded as GRAPHIC. This allows a direct comparison between GRAPHIC and NOGRAPHIC groups. Again, single factor ANOVA was used to search for significant differences between the groups. The results, shown in Table 12, indicate a significant difference (p=.0002) between the GRAPHIC and NOGRAPHIC groups. Thus, the null hypotheses for H3a, which states that there is no difference between the mean estimates of
proportion for the GRAPHIC and NOGRAPHIC groups, is rejected.

Table 10. Phase I.A: Base-Rate Neglect
Main and Interaction Effects

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUP</td>
<td>5713.278</td>
<td>2</td>
<td>2856.639</td>
<td>7.132</td>
<td>.001</td>
</tr>
<tr>
<td>VERBAL</td>
<td>845.861</td>
<td>1</td>
<td>845.961</td>
<td>2.112</td>
<td>.148</td>
</tr>
<tr>
<td>VISUAL</td>
<td>208.140</td>
<td>1</td>
<td>208.140</td>
<td>1.520</td>
<td>.472</td>
</tr>
<tr>
<td>GROUP*VERBAL</td>
<td>560.291</td>
<td>2</td>
<td>280.146</td>
<td>.699</td>
<td>.498</td>
</tr>
<tr>
<td>GROUP*VISUAL</td>
<td>38.283</td>
<td>2</td>
<td>19.119</td>
<td>.048</td>
<td>.953</td>
</tr>
<tr>
<td>VERBAL*VISUAL</td>
<td>312.459</td>
<td>1</td>
<td>312.459</td>
<td>.780</td>
<td>.378</td>
</tr>
<tr>
<td>GROUP<em>VERBAL</em>VISUAL</td>
<td>1380.505</td>
<td>2</td>
<td>690.252</td>
<td>1.723</td>
<td>.181</td>
</tr>
</tbody>
</table>

Table 11. Phase I.A: Base-Rate Neglect
ANOVA between PIE and PICT

<table>
<thead>
<tr>
<th>Group</th>
<th>Count</th>
<th>Mean</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIE</td>
<td>51</td>
<td>49.471</td>
<td>443.254</td>
</tr>
<tr>
<td>PICT</td>
<td>54</td>
<td>50.407</td>
<td>437.038</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>23.019</td>
<td>1</td>
<td>23.019</td>
<td>.052</td>
<td>.819</td>
</tr>
</tbody>
</table>

Table 12. Phase I.A: Base-Rate Neglect
ANOVA between GRAPHIC and NOGRAPHIC

<table>
<thead>
<tr>
<th>Group</th>
<th>Count</th>
<th>Mean</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAPHIC</td>
<td>105</td>
<td>49.952</td>
<td>436.046</td>
</tr>
<tr>
<td>NOGRAPHIC</td>
<td>100</td>
<td>60.520</td>
<td>355.666</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>5719.917</td>
<td>1</td>
<td>5719.917</td>
<td>14.413</td>
<td>.0002</td>
</tr>
</tbody>
</table>
Figure 10. Base-Rate Neglect: Frequency Distributions

Figure 11. Base-Rate Neglect: Frequency Distributions
Discussion. The frequency distributions for the GRAPHIC and NOGRAPHIC groups are shown in Figures 10 and 11. The mean response for the (NOGRAPHIC) group was 60.52 (see Figure 10). Forty-seven percent (47%) of the subjects gave a response (e.g., 70%) based on individuating information alone. These results are similar to those reported by Bar-Hillel (1980), indicating that subjects tended to neglect base rate information in favor of the worthless individuating information. Yates (1990) states that a collection of probability judgments is biased if the average judgment is too high or too low, relative to the base rate for the target proportion or event.

Figure 11 shows that the mean estimate for the GRAPHIC group (49.95) was closer to the base rate i.e. less biased than the NOGRAPHIC group (see Figure 10). In addition, the percentage of subjects who based their response solely on the individuating information dropped to 32.38%. These results suggest that subjects in the treatment group put less emphasis on the individuating information and gave more weight to the overall base rate.

The representativeness heuristic described by Tversky and Kahneman (1974) can be used to explain the base rate neglect in the control (NOGRAPHIC) group. Since the question under consideration identifies a married person, the statistics dealing with married couples seem more representative of the special case. The individuating
information seems more specific than the overall base rate, so the base rate tends to be ignored.

The impact of the graph is consistent with the visual salience effect and the availability model. According to Jarvenpaa (1990), the visual salience of a portion of an information display can affect both the order in which information is acquired and the relative attention given to the information. In this case, the graph illustrating the base rates is easily distinguished from the accompanying alphanumeric information, lowering the cognitive effort required to acquire the data. This increases the availability of the item for inclusion in the decision-making process. The results suggest that the subjects increased the amount of differential weight, or what Arkes and Hammond (1986) call subjective utilization, assigned to the base rate information, thus reducing the base-rate-neglect bias. The results clearly demonstrate that changes in the visual salience of specific items of information can alter the impact of base-rate neglect. These results are largely consistent with the availability model. However, one inconsistency was discovered. The proposed moderating effect of learning style was not found to be significant.

Phase I.B - The Framing Effect

The main objective of this portion of the experiment was to test hypothesis H6 which states that visual salience
has no impact on the framing effect. Multiple measures were used to test for significance between groups. The response modes included both a dichotomous choice (Yes/No) and a rating scale (1-10). The Z-test of proportion was used on the dichotomously scored data and ANOVA was used to analyze the respondents' rating of the quality of the investment.

**Results.** Analysis of the proportions of respondents willing to make the investment provided evidence of a framing effect for both the GRAPHIC and NOGRAPHIC groups. As seen in Figure 12, the proportion of subjects willing to make the investment was lower in the NEGATIVE frame and higher in the POSITIVE frame for both groups. These results are consistent with the findings of Levin et al. (1986). However, the Figure 12 also shows that for the GRAPHIC group, the framing effect, i.e., the magnitude of the difference in the proportion of affirmative responses between the POSITIVE and NEGATIVE frames, is substantially reduced. The framing effect was reduced from .26 for the NOGRAPHIC group to only .04 for the GRAPHIC group. The proportions and sample sizes for each cell are shown in Table 13. The framing effect for the NO GRAPHIC group was statistically significant at alpha = .05 (Z=2.765 p=.0058). In contrast, the framing effect for the GRAPHIC group was not statistically significant (Z=.447, p=.6528); thus providing evidence to reject the null hypothesis H6a which
states that there is no difference in the framing effect between the GRAPHIC and NOGRAPHIC groups based on the proportion taking the trade. The respondents' ratings of the quality of the investment are illustrated by Figure 13. The mean ratings and cell sizes are shown in Table 14. These data were analyzed using ANOVA (see Table 15). The results indicate significant effects for the frame, i.e., the framing effect, and a FRAME*GRAPH interaction which is significant at the .05 level (p=.007). Utilizing evidence from subjects' ratings of the perceived quality of the trading opportunity, the results indicate statistically significant framing effects for the NOGRAPHIC condition and no statistically significant framing effect associated with the GRAPHIC treatment. This provides evidence to reject the null hypothesis H6b which states that there is no difference in the framing effect between the GRAPHIC and NOGRAPHIC groups based on the perceived quality of the trade.

Table 13. Framing Effect - Proportions and Cell Sizes

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>NOGRAPHIC</th>
<th>GRAPHIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRAME</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>52% (n=50)</td>
<td>32% (n=52)</td>
</tr>
<tr>
<td>Negative</td>
<td>26% (n=50)</td>
<td>28% (n=53)</td>
</tr>
</tbody>
</table>
Table 14. Framing Effect - Mean Ratings and Cell Sizes

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>NOGRAPHIC</th>
<th>GRAPHIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRAME</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>5.38 (n=50)</td>
<td>4.25 (n=52)</td>
</tr>
<tr>
<td>Negative</td>
<td>3.88 (n=50)</td>
<td>4.28 (n=53)</td>
</tr>
</tbody>
</table>

Table 15. Phase I.B: Framing Effect
Main and Interaction Effects

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRAME</td>
<td>26.187</td>
<td>1</td>
<td>26.187</td>
<td>6.454</td>
<td>.012</td>
</tr>
<tr>
<td>GRAPH</td>
<td>6.635</td>
<td>1</td>
<td>6.635</td>
<td>1.635</td>
<td>.202</td>
</tr>
<tr>
<td>FRAME*GRAPH</td>
<td>30.092</td>
<td>1</td>
<td>30.092</td>
<td>7.416</td>
<td>.007</td>
</tr>
</tbody>
</table>

Figure 12. Framing Effect - Proportions
Discussion. The framing effect occurs when decision makers focus on the frame instead of the underlying probabilities of the problem. Two possible impacts from the addition of the graph to the display are consistent with the availability model and help explain the reduction in the framing effect observed in this experiment. First, the graphics size and shape differentiate it from the text, thus increasing the visual salience of the information contained in the graphs (e.g., the underlying probabilities).
According to the availability model, this causes the subjects to increase the decision weight (subjective utilization) assigned to the probabilities in the decision process, thereby reducing the relative importance of the frame. A second possible explanation for the influence of the graphic treatment does not rely on the visual salience effect but is still consistent with the availability model. The original text display gives only one side of the probability information. The alternative probability must be inferred. For example, given that "the probability of winning is 20%," one must infer the 80% probability of losing. The addition of the pie chart makes the alternative probability explicit. This reduces the cognitive effort required to integrate the information, thus increasing its availability. Both explanations are consistent with the finding that changes in presentation format which increased the availability of the underlying probabilities resulted in a decrease of the framing effect, as predicted by the availability model.

Phase I.C - Anchoring-and-Adjustment

The main purpose of this portion of the experiment was to test hypothesis H5 which states that visual recency has no impact on biases associated with the anchoring-and-adjustment heuristic. A second purpose was to test for main or interaction effects associated with visual and verbal
learning styles. The presentation mode treatment (MODE) consisted of 1-page or 2-page visual displays.

**Results.** ANOVA was used to test for significant main and interaction effects. The results are summarized in Table 16. The only significant main effect was presentation MODE (n=205, p=.003). The mean estimate for the control group (1-PAGE) was 45.14 compared to 48.05 for the 2-PAGE treatment group. These results provide strong evidence to reject the null hypothesis H5a which states that there is no difference between the mean estimates of sales for the 1-page and 2-page groups.

ANOVA was also used to test for any main or interaction effects with learning style preference. No significant main or interaction effects were discovered. Therefore, these findings fail to reject hypothesis H5b (e.g., there are no differences in the mean estimates of sales due to the interaction of graphic treatments and verbal and visual scores).

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODE</td>
<td>432.221</td>
<td>1</td>
<td>432.221</td>
<td>8.787</td>
<td>.003</td>
</tr>
<tr>
<td>VISUAL</td>
<td>37.136</td>
<td>1</td>
<td>37.136</td>
<td>.755</td>
<td>.386</td>
</tr>
<tr>
<td>VERBAL</td>
<td>118.803</td>
<td>1</td>
<td>118.803</td>
<td>2.415</td>
<td>.122</td>
</tr>
<tr>
<td>MODE*VISUAL</td>
<td>.824</td>
<td>1</td>
<td>.824</td>
<td>.017</td>
<td>.897</td>
</tr>
<tr>
<td>MODE*VERBAL</td>
<td>.959</td>
<td>1</td>
<td>.959</td>
<td>.019</td>
<td>.889</td>
</tr>
<tr>
<td>VISUAL*VERBAL</td>
<td>80.823</td>
<td>1</td>
<td>80.823</td>
<td>1.643</td>
<td>.201</td>
</tr>
<tr>
<td>MODE<em>VISUAL</em>VERBAL</td>
<td>23.763</td>
<td>1</td>
<td>23.763</td>
<td>.483</td>
<td>.488</td>
</tr>
</tbody>
</table>
Discussion. The theoretical basis of the 1-PAGE versus 2-PAGE treatment rests on the availability bias by which more weight is given to information that is easy to recall (Tversky and Kahneman 1974) and on the recency effect by which more recently imparted information has more impact on decision making (Taylor and Thompson 1982). The anticipated effect of the 2-PAGE treatment was for higher estimates based on the assumption that the recency effect would cause the apparent trend exhibited on page two to be more available to the decision maker and that this would cause subjects to adjust estimates higher. The results supported the anticipated effect and are consistent with the availability model. The results are also consistent with the findings of Dreben et al. (1979) who concluded that recency affects judgment by making the final item of information more available in the visual (attentional) field.

Phase II.B of this study indicated that over eighty percent of the respondents to this task used an anchoring-and-adjustment heuristic. Therefore, the observed significant differences can be said to be a result of altering the outcomes of an anchoring-and-adjustment heuristic through changes in visual recency.
Phase II.A - Perceived Importance

The purpose of this phase of the experiment is to test hypothesis H2 which states that visual salience has no impact on the perceived importance of items. Two response modes were used to collect data. Subjects were asked to rate the importance of each item on a seven-point Likert-type scale. They were also asked to rank the relative importance of each of 5 items from the visual display.

Results. Table 17 shows the results of a one way ANOVA comparing the ratings for the perceived absolute importance of the base rates. Although the rating of the perceived importance is slightly higher in the GRAPHIC group (mean = 3.91) compared to the NOGRAPHIC group (mean = 3.70), the difference is not statistically significant at the alpha = .05 level (p=.452). Thus the results fail to reject hypothesis H2a, which states that there is no difference in the mean perceived importance of the base-rate between the GRAPHIC and NOGRAPHIC groups.

Rankings were used to determine the perceived relative importance of each of the five items in the visual display. The Mann-Whitney U test was used to search for differences in the relative rankings between the GRAPHIC and NOGRAPHIC treatment groups. The results for the perceived relative importance of the base rate are reported in Table 18. The results demonstrate a significant difference (p=.006) between the ranking assigned to the base rate in the GRAPHIC
and NOGRAPHIC treatment groups. There were no significant differences discovered for any of the other items of information in the visual display. These results support rejection of hypothesis H2b (e.g., there is no difference in the rankings of the perceived importance of the base-rate between the GRAPHIC and NOGRAPHIC groups).

Table 17. Phase II.A: Perceived Importance ANOVA between GRAPHIC and NOGRAPHIC

<table>
<thead>
<tr>
<th>Group</th>
<th>Count</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAPHIC</td>
<td>104</td>
<td>3.91</td>
</tr>
<tr>
<td>NOGRAPHIC</td>
<td>100</td>
<td>3.70</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>2.323</td>
<td>1</td>
<td>2.323</td>
<td>.567</td>
<td>.452</td>
</tr>
</tbody>
</table>

Table 18. Phase II.A: Mann-Whitney U test Perceived Relative Importance (rankings) of the base rate between GRAPHIC and NOGRAPHIC treatments

<table>
<thead>
<tr>
<th>Group</th>
<th>Count</th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAPHIC</td>
<td>103</td>
<td>90.83</td>
</tr>
<tr>
<td>NOGRAPHIC</td>
<td>99</td>
<td>112.60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>U</th>
<th>W</th>
<th>Z</th>
<th>Corrected for ties</th>
</tr>
</thead>
<tbody>
<tr>
<td>4000.0</td>
<td>11147.0</td>
<td>-2.7392</td>
<td>2-Tailed P</td>
</tr>
</tbody>
</table>

Discussion. The results indicate that the addition of a pie chart illustrating the base rate did not significantly effect the absolute perceived importance of the base rate (see Table 18). However, the treatment did alter the relative importance of the base rate compared to the other
items in the visual display. These findings are consistent with the concept of visual salience. The addition of the pie chart was designed to increase the visual salience of the base rate. Visual salience refers to the differential or relative attention given to elements in a visual display (Taylor and Thompson 1982). The link between attention and relative importance is consistent with the findings of Mackenzie (1986) who found that the amount of attention focused on an attribute had a direct effect on the perceived relative importance of that attribute. The perceived relative importance of an item has been interpreted as an indicator of the item's decision weight parameter, also known as subjective utilization (Schwartz and Norman 1989; Weber 1994).

The results are consistent with Anderson's (1981) item integration theory which contends that decision weights must sum to one, implying that decision weight is a relative and not an absolute construct. In addition, the results support the local interpretation of Anderson's (1981) theory which holds that an item's relative importance, and thus weight parameter, is affected by the problem presentation or stimuli (Goldstein 1990). Therefore, the results of this experiment provide evidence to support the proposed link in the availability model between visual salience and subjective utilization.
Phase II.B - Decision Strategy

This portion of the study was non-experimental. The respondents simply answered a questionnaire to determine the decision strategy used during the sales estimation task. A one tailed Z-test of proportion was used to determine if more than 50% of the population used the anchoring-and-adjustment strategy.

Results. A total of 164 or 80.8% of the 203 respondents chose the anchoring-and-adjustment strategy. Testing the null hypothesis that the proportion of respondents using the anchoring-and-adjustment strategy was less than or equal to .5 (e.g., H0: p<.5), results in a rejection of the null hypotheses (n=203, Z=8.77, p<.001).

Discussion. These results support the contention that the sales estimation task used in phase I.C does induce a majority of respondents to utilize the anchoring-and-adjustment heuristic. This is consistent with the findings of Cox and Summers (1987) who found that professional buyers used the same heuristic to estimate sales when the information was presented in a tabular format. This finding allows one to infer that treatments which significantly impact the responses to the sales estimation task are, in fact, altering the outcomes of an anchoring-and-adjustment heuristic.
Phase II.C - Recall

The purpose of this phase of the experiment was to determine whether visual salience improves recall, a surrogate for availability. A Z-test of proportion was used to test for significant differences in the proportion of subjects who accurately recalled the base rate between the GRAPHIC and NOGRAPHIC groups.

Results. There were 104 usable responses in the GRAPHIC group and 98 usable responses in the NOGRAPHIC group. A total of 60 (61.22%) of the NOGRAPHIC group successfully recalled the base rate. In comparison, 96 (92.31%) of the GRAPHIC group were able to recall the base rate. The difference in the proportions between the two groups is statistically significant at the .05 level (Z=5.5859, p < .001). The results provide evidence to reject hypothesis H1a which states that there is no difference in the proportion of subjects who accurately recall the base-rate between the GRAPHIC and NOGRAPHIC groups.

Discussion. Recall has often been used as a surrogate for availability, which has been described as the ease with which information is brought to mind (Tversky and Kahneman 1974). An availability bias is said to exist when the information most easily brought to mind is influenced by possibly irrelevant factors such as salience (Taylor and Thompson 1982). In this experiment, the addition of a
graphic image was used to increase the visual salience of the base rate. This treatment was similar to that used in experiment I.A which investigated base-rate neglect. The task used in this experiment was a true recall task. Subjects were required to recreate the experimental stimuli from memory. The results of the experiment indicate significantly improved recall of the base-rate information among those subjects who received the graphic treatment, contradicting the results of Watson and Driver (1983), who found no improvement in recall attributable to the use of a graphic presentation format. The results of this study support the proposition, contained in the availability model, that visual salience increases the availability of items.

Analysis of Results

Phase I investigated the impact of variations in presentation format on cognitive biases. The cognitive biases under investigation were base-rate neglect, the framing effect, and insufficient adjustment associated with the anchoring-and-adjustment heuristic. This portion of the study treated the decision process as a "black box". The presentation format, or input to the system, was manipulated, and the subjects' judgment, or output, was measured. The results of the statistical hypotheses tests are summarized in Table 19.
The results indicated support for the alternative versions of all major substantive hypotheses. In phase I.A, visual salience was found to impact base-rate neglect. Specifically, increasing the visual salience of the base rate by adding a graph to the display resulted in a decrease in base-rate neglect. The results from phase I.B demonstrated that visual salience also altered the framing effect. The framing effect was diminished when a graph which represented the underlying probabilities was added to the problem presentation. The results of phases I.C and II.B combine to demonstrate the impact of visual recency on the anchoring-and-adjustment heuristic. The results of phase I.C demonstrated that visual recency impacted judgments associated with the sales-estimation task. The information on the final page of a two-page display disproportionately influenced the subjects' judgment. The results from phase II.B confirmed that over eighty percent of the subjects used the anchoring-and-adjustment heuristic for the sales-estimation task. It can therefore be concluded that visual recency altered the judgment of subjects using the anchoring-and-adjustment heuristic.

The three independent experiments in phase I were conducted using a variety of tasks and graphic manipulations. The results provide empirical evidence to indicate that the research question driving this study can be answered in the affirmative. Changes in presentation
format can be used to alter the effects of cognitive biases in human decision making. The effects of the experimental treatments on the subjects’ judgment were consistently significant and in the direction predicted by the availability model, providing empirical evidence to support a portion of that model.

However, one portion of the availability model was not supported. Two secondary hypotheses were tested which sought to determine whether the effects of changes in presentation format on biases and heuristics were moderated by the learning style of the user. No main or interaction effects attributable to learning style were discovered. The lack of evidence for a significant effect from learning style lends support to those who doubt the efficacy of cognitive style as a basis for the design of decision support systems. The learning style of the subjects appeared to have little impact on their responses to the experimental tasks even though the treatments dealt directly with visual and verbal presentation modes. The proposed impact of learning style was the only portion of the availability model which was not supported by the results of this study.

The experiments in phase II represented an attempt to peer inside the "black box" of the subjects' cognitive decision-making processes. As noted above, phase II.B was used to confirm an assumption about the cognitive effect of
the experimental stimuli used in phase I.C. The results of phase II.C demonstrated that increasing the visual salience of an item of information through the addition of a graph significantly increased recall of that information. Recall was used as a surrogate for the availability construct. Therefore, these results suggest that increasing the visual salience of an item increases its availability. This verifies the proposed link in the availability model between these two constructs. Phase II.A investigated the relationship between availability and subjective utilization. The results indicated that increasing the availability of an item resulted in an increase in the perceived relative importance of the item. Perceived importance was used as a surrogate for subjective utilization. Thus, the results from phase II.A support the existence of a link between availability and subjective utilization as proposed in the availability model. The findings from phase II provide evidence to verify the intermediate links in the model between a change in presentation format and the observed differences in judgment.

Summary of Hypotheses Tests

Table 19 summarizes the results of the study. Column one contains each substantive hypothesis, in bold, followed by its statistical hypotheses. The results of the
statistical tests are presented in column two along with the corresponding p-values.

Table 19. Summary of Results

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Result (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H1 Visual salience has no impact on the recall of items.</strong></td>
<td></td>
</tr>
<tr>
<td>H1a There is no difference in the proportion of subjects who accurately recall the base-rate between the GRAPHIC and NOGRAPHIC groups.</td>
<td>Reject (p=.001)</td>
</tr>
<tr>
<td><strong>H2 Visual salience has no impact on the perceived importance of an item in a visual display.</strong></td>
<td></td>
</tr>
<tr>
<td>H2a There is no difference in the mean perceived importance of the base-rate between the GRAPHIC and NOGRAPHIC groups.</td>
<td>Fail to Reject (p = .452)</td>
</tr>
<tr>
<td>H2b There is no difference in the rankings of the perceived importance of the base-rate between the GRAPHIC and NOGRAPHIC groups.</td>
<td>Reject (p = .006)</td>
</tr>
<tr>
<td><strong>H3 Visual salience has no impact on base-rate neglect.</strong></td>
<td></td>
</tr>
<tr>
<td>H3a There is no difference between the mean estimates of proportion for the GRAPHIC and NOGRAPHIC groups.</td>
<td>Reject (p = .0002)</td>
</tr>
<tr>
<td>H3b There are no differences in the mean estimates due to the interaction of graphic treatments and verbal and visual scores.</td>
<td>Fail to Reject (p = .181)</td>
</tr>
</tbody>
</table>
Table 19. Summary of Results (continued)

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Result (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H4</strong> The sales estimation task does not cause a majority of subjects to use the anchoring-and-adjustment heuristic.</td>
<td></td>
</tr>
<tr>
<td>H4a The proportion of subjects using the anchoring-and-adjustment heuristic for the sales estimation task is less than or equal to .50.</td>
<td>Reject (p &lt; .001)</td>
</tr>
<tr>
<td><strong>H5</strong> Visual recency has no impact on biases associated with the anchoring-and-adjustment heuristic.</td>
<td></td>
</tr>
<tr>
<td>H5a There is no difference between the mean estimates of sales for the GRAPHIC and NOGRAPHIC groups.</td>
<td>Reject (p = .003)</td>
</tr>
<tr>
<td>H5b There are no differences in the mean estimates of sales due to the interaction of graphic treatments and verbal and visual scores.</td>
<td>Fail to Reject (p = .488)</td>
</tr>
<tr>
<td><strong>H6</strong> Visual Salience has no impact on the framing effect.</td>
<td></td>
</tr>
<tr>
<td>H6a There is no difference in the framing effect between the GRAPHIC and NOGRAPHIC groups based on the proportion taking the trade.</td>
<td>Reject N/A</td>
</tr>
<tr>
<td>H6b There is no difference in the framing effect between the GRAPHIC and NOGRAPHIC groups based on the perceived quality of the trade.</td>
<td>Reject (p = .007)</td>
</tr>
</tbody>
</table>
CHAPTER REFERENCES


CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

This chapter begins with a restatement of the problem motivating the study. Next, the procedures used in the research are briefly reviewed. A synopsis of the results and the significance of the findings are presented. The chapter concludes with a discussion of the limitations of the study and directions for future research.

Statement of Problem

The problem motivating this study is twofold. The first part of the problem is the sub-optimal decision making caused by the use of heuristics and their associated cognitive biases. The second part of the problem is the lack of a theoretical basis to guide the design of information presentation formats to counter the effects of such biases. The research question investigated by this study was "Can changes in presentation format be used to alter the effects of cognitive biases in human decision making?"

Review of the Study

The search to find an answer to the research question began with a review of the related literature (see Chapter
II). This review focused on the areas of behavioral decision making, biases and heuristics, and the cognitive effects of various presentation formats. Emerging from this review were five propositions based on previous research:

1. Uncertainty leads to the use of heuristics (Tversky and Kahneman 1974).

2. The use of heuristics leads to predictable biases (Tversky and Kahneman 1974).

3. Biases can be attributed to errors in subjective utilization (also known as relative decision weight) (Arkes and Hammond 1986; Weber 1994).

4. The availability bias occurs when subjective utilization is increased by recency or salience (Taylor and Thompson 1982; Mackenzie 1986).

5. Recency and salience effects can be created through changes in presentation format (Jarvenpaa 1990; Weber 1994).

These findings demonstrated that an IS designer might purposefully create an availability bias through changes in presentation format in order to increase the subjective utilization of a specific item of information and thereby modify the effects of other cognitive biases.

The propositions listed above were combined with earlier research frameworks and variables from previous studies to create an availability model for the effects of changes in presentation format on biases and heuristics (see
Chapter III, Figure 4). In an attempt to verify the availability model and answer the research question, a series of six laboratory experiments was conducted. These experiments were divided into two phases. Phase I investigated the impact of changes in presentation format on specific biases and heuristics. Phase II tested assumptions pertaining to the availability model and the cognitive impact of the experimental stimuli.

The results of phase I indicate that altering the availability of items through changes in presentation format can alter the impact of cognitive biases on decision making. More specifically, the results demonstrate that changes in the visual salience or visual recency of items of information in a visual display can alter the impact of base-rate neglect, the framing effect, and the biases associated with the use of the anchoring-and-adjustment heuristic.

The results of phase II provided evidence to support two important links in the availability model. The results of phase II.A indicate that increasing the availability of an item increases the perceived relative importance of the item. The results of phase II.C clearly demonstrate that increasing the visual salience of an item of information leads to increased recall of that item.
Significance of the Findings

This study has demonstrated that changes in presentation format can alter the impact of cognitive biases on decision making. Moreover, the experimental results substantially validate the availability model, except for the proposed impact of learning style. These findings have significant implications for both practitioners and researchers related to the design of decision support systems and other computer generated decision aids.

In general, the availability model suggests that a designer can purposefully increase the subjective utilization of an item of information, and thus its impact on final judgment, by increasing that item's availability through changes in the presentation format which increase either the visual salience or visual recency of the item. This general guidance can be used to suggest specific recommendations for moderating the impact of biases and heuristics in computer-aided decision making.

Base-rate neglect occurs when the subjective utilization of the base rate is too low. The subjective utilization can be increased by increasing the availability of the base rate through the addition of a graphic image (e.g., a pie chart or pictogram) which illustrates the base-rate information. The use of this presentation format should result in a reduction in base-rate neglect, all other factors being equal.
The framing effect can be traced to a relatively high subjective utilization of irrelevant framing information in comparison to the underlying probabilities or other information relevant to the problem. Care should always be taken to present information in a neutral frame of reference. However, for problems in which framing effects are observed or suspected, these biases may be moderated by increasing the availability of the underlying probabilities through the inclusion in the presentation of a graphic image depicting those probabilities.

Anchoring-and-adjustment is a heuristic which is commonly used to make judgments concerning future events based on knowledge of past performance. The results of this study suggest that in support of this type of decision making, all of the relevant information should be placed in the same visual field in order to avoid any unintended influence on final judgment which might be attributable to the recency effect.

In addition to providing guidance to the designers of computer generated output, the results of this study also provide a warning. These findings present a picture of the user as a person whose decision-making behavior is stimulus driven and whose judgment is unduly influenced by irrelevant changes in presentation format. This interpretation supports Todd and Benbasat's (1991) conclusion that seemingly minor changes in presentation format may have
substantial unintended influence on the subsequent decision making behavior of systems users. Instead of being based on theory, the design of presentation formats is typically an ad-hoc process, often based on the preferences of either the user or the designer, with little thought given the cognitive impact of the final presentation format. The potential for inadvertently creating an adverse impact on the quality of computer-supported decision making is likely to increase as new technologies, such as multimedia and hypertext, provide the designer with powerful new tools for altering the availability of items through changes in visual salience or recency.

In order to combat the potential problems associated with atheoretical design methods, it will be necessary to develop a more general theory of output design. This study represents a small step toward that goal. This study does not purport to demonstrate a general theory of output design, but by allowing the designer to predict, a priori, the impact of specific changes of presentation format on subsequent decision making behavior, this study adds to the body of knowledge needed to construct a more general theory.

Limitations

The generalizability of laboratory experiments is problematic. Realism is often sacrificed in order to improve internal control (Kerlinger 1986). The presentation
effects demonstrated in this study are highly task specific. In addition, only a single task was used to investigate each cognitive bias. This raises the question of whether any significant results can be generalized to apply to other tasks for which people display the same bias.

The tasks chosen for this investigation were selected because they were supported by prior research and have been demonstrated to produce the desired biases. Although the tasks have been modified to be more relevant in a business context, they do not represent actual DSS supported business tasks.

Another potential limitation of the study was the sole reliance on graphs for increasing the visual salience of items of information. Other treatments such as color, movement, or variations in the size and type of a text font are also potential methods of increasing visual salience.

The use of students in behavioral research may be considered a threat to the external validity of the study (Khera and Benson 1970; Copeland, Francia, and Strawser 1973; Ashton and Kramer 1980; Gordon, Slade, and Schmitt 1986). However, even critics of the use of student surrogates concede that students could be adjudged appropriate when the task involved requires no special skill or experience (Khera and Benson 1970), or when there is an a priori theoretical or empirical justification for their use (Gordon, Slade, and Schmitt 1986). Both of these
stipulations have been met by the conditions of the current study. The knowledge lean tasks used in this investigation require no special skill or knowledge beyond the general educational level of the subjects. In addition, at least three studies have indicated no significant difference in the use of heuristics and biases between students and experienced business professionals (Mowen and Mowen 1986; Cox and Summers 1987; Northcraft and Neal 1987). These facts, especially when combined with the finding that the majority of the subjects in the study were currently employed, should serve to reduce the threat to external validity from the use of student subjects.

Directions for Future Research

In order to further validate the availability model, and to improve its generalizability, a field study should be conducted. Such a study could investigate the impact of an integrated decision support system on a task which is known to illicit one or more of the cognitive biases discussed in this investigation.

Multimedia and hypermedia offer new opportunities for designers of computer generated presentations and new challenges for researchers hoping to understand the cognitive effects of these increasingly complex presentation formats. Although this study used graphs to increase the visual salience of particular items of information, the
availability model should not be interpreted in terms of a
tables versus graphs dichotomy. In order to further
validate this model, other methods of creating increased
visual salience such as motion, color, and variations in
font size should be investigated.

Hypertext and hypermedia offer the user considerable
freedom to choose the temporal order of information
presentation. However, this study has demonstrated that
ordering effects, such as recency, can impact decision-
making behavior. Researchers should investigate the effects
of variations in user-selected paths through a hypermedia
presentation on subsequent decision-making behavior. If the
recency effect demonstrated by the current study is
detected, it would represent an unintended and potentially
negative consequence of providing the user with increased
flexibility in information acquisition.

Finally, attempts should be made to integrate the
various models and theories concerning the efficacy of
different presentation formats in support of decision
making. The theoretical models used by Jarvenpaa (1990),
Todd and Benbasat (1991), and the current study, as well as
Vessey's (1991) cognitive fit theory are all based, at least
in part, on Payne's (1982) contingent decision behavior
theory and the concept of cognitive cost/benefit. Payne's
theory is therefore suggested as a potential starting point
for integrating these different theoretical perspectives.
Conclusions

In summary, an understanding of how people extract and use information from a visual display is important for designing presentation formats that maximize the particular desired effect of the display (DeSanctis 1984). The results of this investigation demonstrate that by using our knowledge of cognitive processes (e.g., the visual salience effect, the visual recency effect, and the availability heuristic), presentation formats can be altered in order to moderate the effects of certain biases and heuristics in human decision making. An understanding of these results may be useful in improving DSS design.
CHAPTER REFERENCES


APPENDIX A

REVISED VVQ
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Revised VVO</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SSN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>M / F</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Status</strong></td>
<td>Fr. So. Jr. Sr. Grad.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Are you currently employed?</strong></td>
<td>Y / N</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>If yes, Part Time / Full Time; No. months</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1.</strong></td>
<td>T / F -</td>
<td>I enjoy work that requires the use of words.</td>
<td></td>
</tr>
<tr>
<td><strong>2.</strong></td>
<td>T / F -</td>
<td>I enjoy learning new words.</td>
<td></td>
</tr>
<tr>
<td><strong>3.</strong></td>
<td>T / F -</td>
<td>I can easily think of synonyms for words.</td>
<td></td>
</tr>
<tr>
<td><strong>4.</strong></td>
<td>T / F -</td>
<td>I read rather slowly.</td>
<td></td>
</tr>
<tr>
<td><strong>5.</strong></td>
<td>T / F -</td>
<td>I prefer to read instructions about how to do something rather than have someone show me.</td>
<td></td>
</tr>
<tr>
<td><strong>6.</strong></td>
<td>T / F -</td>
<td>I have better than average fluency in using words.</td>
<td></td>
</tr>
<tr>
<td><strong>7.</strong></td>
<td>T / F -</td>
<td>I spend little time attempting to increase my vocabulary.</td>
<td></td>
</tr>
<tr>
<td><strong>8.</strong></td>
<td>T / F -</td>
<td>I dislike word games like crossword puzzles.</td>
<td></td>
</tr>
<tr>
<td><strong>9.</strong></td>
<td>T / F -</td>
<td>I dislike looking up words in dictionaries.</td>
<td></td>
</tr>
<tr>
<td><strong>10.</strong></td>
<td>T / F -</td>
<td>I have a hard time remembering the words to songs.</td>
<td></td>
</tr>
<tr>
<td><strong>11.</strong></td>
<td>T / F -</td>
<td>I don’t believe that anyone can think in terms of mental pictures.</td>
<td></td>
</tr>
<tr>
<td><strong>12.</strong></td>
<td>T / F -</td>
<td>I find illustrations or diagrams help me when I'm reading.</td>
<td></td>
</tr>
<tr>
<td><strong>13.</strong></td>
<td>T / F -</td>
<td>I have a hard time making a &quot;mental picture&quot; of a place I've only been to a few times.</td>
<td></td>
</tr>
<tr>
<td><strong>14.</strong></td>
<td>T / F -</td>
<td>I seldom use diagrams to explain things.</td>
<td></td>
</tr>
<tr>
<td><strong>15.</strong></td>
<td>T / F -</td>
<td>I like newspaper articles that have graphs.</td>
<td></td>
</tr>
<tr>
<td><strong>16.</strong></td>
<td>T / F -</td>
<td>I don’t like maps or diagrams in books.</td>
<td></td>
</tr>
<tr>
<td><strong>17.</strong></td>
<td>T / F -</td>
<td>When I read books with maps in them, I refer to the maps a lot.</td>
<td></td>
</tr>
<tr>
<td><strong>18.</strong></td>
<td>T / F -</td>
<td>The old saying &quot;A picture is worth a thousand words&quot; is certainly true for me.</td>
<td></td>
</tr>
<tr>
<td><strong>19.</strong></td>
<td>T / F -</td>
<td>I have always disliked jigsaw puzzle.</td>
<td></td>
</tr>
<tr>
<td><strong>20.</strong></td>
<td>T / F -</td>
<td>I find maps helpful in finding my way around a new city.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B

DECISION STRATEGY QUESTIONNAIRE
Decision Strategy Questionnaire

SSN ____________________________

Please refer to the Quarterly Sales Estimation display (the bar chart) in order to answer this question.

Please read all of the possible decision strategies before choosing your answer. There is NO preferred answer to this question. It is important that you select that strategy which most closely matches the one that you utilized to solve the sales estimation problem.

Please circle the number corresponding to the decision strategy which most closely matches yours.

1. I chose a number at random between the highest and lowest numbers represented in the chart.

2. I selected a quarter from the past to use as a starting point and adjusted my estimate (up or down) from that point, based on the trend.

3. I used a mathematical formula to estimate the sales.

4. If none of the above strategies accurately describe how you solved the problem, please describe your method in your own words in the space provided.
APPENDIX C

SUBJECTS’ RESPONSES TO SALES ESTIMATION TASK
Subject Responses to the Sales Estimation Task

Subject #1

1. Sales for 3rd quarter = up by 5 million from 3rd quarter of 92.

2. How - as 1&2 grow, 3 increases proportionately to the growth with the sum of 1,2, and 4. 3 balances out the difference between the growth. Assuming the growth follows the pattern
   1. 4 is greater than 1 but less than 2, 3 balances
   2. 4 is greater than 1 and 2, 3 balances
   3. is a repeat of #1
   4. four should balance out as in #2

Historical

Subject #2

3Q93 sales estimate: 50 million

Reasoning
   1. 3Q sales increased each year since 90
   2. 3Q sales less than 2Q sales each year since 90

So the smaller figure I chose is greater than 3Q92 and less than 2Q93.

Subject #3

45 million 3rd qtr.

3rd quarter had been low historically but something changed in the last third quarter. It was still low but was higher than before. Some change, a business decision or environmental change, caused sales to be higher. Based on the assumption that the change is permanent, sales should be just as high this year.

Subject #4

Estimated sales for 3rd Quarter 93 sales - 48 million.

This is based on the 3rd quarter sales of 90 and 91 compared to the 2nd quarter sales of 90 and 91. The 2nd quarter sales of 90 and 91 were almost the same with the 3rd quarter of 91 sales slightly higher than 90. The 2nd quarter sales of 92 and 93 are almost the same. So I am concluding that the 3rd quarter sales will be slightly higher than the 3rd quarter of 92.
Subject #5

3 Quarter of 93 will be around 45,000,000.

I arrived there by looking at 90, 91, 92 - 1&2&3 then estimating from there the 93 3rd quarter. All previous years seemed to be 10 points lower than average.

Subject #6

3rd Quarter sales for 1993 approx. 45 million. Because using trend analysis sales have historically dropped by 10 or more points.

Subject #7

1. Estimated sales: 40 million
2. I determined that every third quarter goes down after high second quarter and I averaged the drop between the second quarter and third in years 90, 91, 92 to get the figure.

Subject #8

3rd quarter 93 sales: 46 million

Over the past few years, sales have decreased in the third quarter as compared to the 3 previous quarters. So the sales will be less than the 3 previous quarters. Also third quarter sales increase each year so the sales in 93 will be greater than 3rd quarter 92.

Subject #9

Estimated sales ? 50 million

How came up w/decision? Every 3rd quarter did less than all other quarters but better than previous 3rd quarter. 2nd quarter w/previous 3rd quarter --> divided difference in half and went with 50 million.

Subject #10

At least 55 million or a little higher ( around 55 1/2 million)

This estimate is based on the upward trend beginning with the third quarter of 92 continuing through 2nd quarter of 93.
Subject #11

1993 3rd Quarter Sales = $45 million

How: Third quarter sales tended to be $10-$15 million less than the other quarters every year. I looked at the 93 quarter 1&2 and took an amount about $10 million less.

Subject #12

3rd quarter 93 sales (millions) would be above 50 millions.
Reason: According to the sales chart, (from year 92-93), the sales is increasing. This give me and idea that the sales is improving and increasing so when it comes to 3rd 93 the sales is increased from 2nd quarter to 50 millions and above.

Subject #13

1. Estimate sales for the 3rd quarter will be 45 million.
2. How I got my answer. Well, I looked in the year 90 and saw 25,000,000 and in the year 91 was 30,000,000 and in the year 92 35,0000,000. So I estimated that in the year of 93 45 million. As long as everything is stable in the industry.

Subject #14

1. 45 millions for the 3rd qtr 93.
2. The pattern of sales in line with the previous 3 qtrs, 90, 91, 92 are about 10 million to 15 million less than the second qtr sales based on the current chart.

Subject #15

Quarter 3 = avg 45
Because the third quarter in the past years seems to drop after the 2nd quarter (on average) by 1/4.

Subject #16

40 Mill
I just chose a number between the lowest and the highest (28, 55)
Subject #17
3rd Quarter sales for 93 I estimate will be 43 million.
Each year, sales are going up for the whole year, but the 3rd quarter is the lowest for each year. So by the amount of sales for the 1st and 2nd quarters of 93, I came to the conclusion of 43 million for the 3rd quarter of 93.

Subject #18
1. 50 million
2. based on the previous year's 3rd quarter sales.

Subject #19
1. 48 million
2. I noticed that sales according to the chart always took a drop in the 3rd quarter and then climbed from that drop. Also I noticed the drop was smaller as time progresses so I went with a small drop to 48 million rather than 45 million.

Subject #20
1. 40 million
2. 3rd quarter sales have significantly dropped over the past 3 years by about 10-15 points (millions).

Subject #21
1. Sales figure = 59 million
2. How = the difference between each 3rd quarter figure was 14 mill & 13 mill respectively, so I added the last 3rd Q figure (45) + 14 = 59 million.

Subject #22
Sales for the next quarter? approx 40 mill.
How? Look at the 3rd quarter they all drop approx 15 mill from 2nd, so therefore I estimated about 40 million.
APPENDIX D

Original and Modified Questions
Original and Modified Tasks

Three decision tasks are used in this study.

1. Base-rate neglect

a. Original question (Bar-Hillel 1980):

Studies of dreaming have shown that 80% of adults of both sexes report that they dream, if only occasionally, whereas 20% claim that they do not remember ever dreaming. Accordingly, people are classified by dream investigators as "Dreamers" or "Nondreamers". In slightly less than 70% of all married couples, husband and wife share the same classification, i.e., both are Dreamers or both are Nondreamers, whereas slightly more than 30% of couples are made up of one dreamer and one nondreamer.

Mrs. X is a Nondreamer.

What do you think are the chances that her husband is also a Nondreamer? ______% 

b. Modified version:

Studies of mail ordering tendencies have shown that 80% of adults of both sexes report that they will order products by mail, if only occasionally, whereas 20% claim that they never order by mail. Accordingly, people are classified by the marketing department as "Buyers" or "Nonbuyers". In slightly less than 70% of all married couples, husband and wife share the same classification, i.e., both are Buyers or both are Nonbuyers, whereas slightly more than 30% of couples are made up of one Buyer and one Nonbuyer.

Mrs. X is a Nonbuyer.

What do you think are the chances that her husband is also a Nonbuyer? ______%
2. Framing effect

a. Original question (Levin et al 1986):

Assume that you have $20. You can either keep the $20 and not play the gamble or pay the $20 and take the gamble.

Amount to be won: $100
Probability of winning is 20% - (positive frame)
Probability of losing is 80%. - (negative frame)

Would you take the gamble? Y/N

b. Modified version:

Assume that you are trading options for a commercial account. Your goal is to maximize the value of your portfolio. The current total account value of the portfolio is approximately $1 million. The total potential loss for options trading is limited to the cost of the investment. The research department has identified a potential trade with the following characteristics:

Cost of the option: $20,000
Potential Return: $115,000
Probability of winning is 20%. - (positive frame)
Probability of losing is 80%. - (negative frame)

Would you take the trade? Y/N

3. Anchoring -and-adjustment biases

a. Original task (Cox and Summers 1987):

The original task was also a sales projection task the only modification is the use of a bar chart instead of a tale to express previous quarter sales numbers.

b. Modified version:

See the Quarterly Sales bar chart in Appendix G.
APPENDIX E

CONSENT FORM
INFORMED CONSENT

The researcher has discussed with me the nature of this investigation, the potential risks and the contribution I will make. The study will be examining the impact of alternative presentation formats on cognitive biases in decision making. The results of this study may be used to provide guidance to the designers of decision support systems.

I understand the following:

1. I am volunteering my participation. I can withdraw from the study at any point. Withdrawal or refusal to participate will result in no penalties or loss of benefits to which I am otherwise entitled.

2. I will spend about 45 minutes observing information displays and responding to simple judgment tasks. In addition, I will fill out the Verbalizer-Visualizer Questionnaire.

3. I agree to disclose the following personal information to assist in the analysis of the responses; age, gender, educational level, and amount of work experience.

4. My individual responses will be confidential and will not be disclosed to anyone other than the principle researcher.

5. Aggregate responses will be disclosed to any interested party.

6. If I have any questions about or problems with this study or my participation in it, I may contact:

   Mr. Thomas P. Van Dyke
   BCIS Department (BUSI 329)
   University of North Texas
   (817) 565-4114

NAME: ________________________________

DATE: ________________________________

This project has been reviewed by the University of North Texas Committee for the Protection of Human Subjects
phone: (817) 565-3946
Start-up Instructions

1. Insert the DOS disk in drive A.
2. Insert the 5 1/4 inch disk in drive B.
3. Reboot the machine.
4. At the "A:\>" prompt type b:[ENTER]
5. At the "B:\>" prompt, type show 1 [ENTER]

You will see a display on the monitor. Use the [PAGE UP] and [PAGE DOWN] keys to move through the pages in the display.

You may now begin responding to the questions on answer sheet #1.
Answer Sheet #1

SSN ———— ———— ————

Note: The order of the computer displays may not match the order of the questions as printed on the answer sheet. Answer the questions in the order that they are displayed on the screen. Match the questions to the answer sheet by the title of the graph, i.e., "Mail Order Survey".

All answers must be recorded on this answer sheet.

1. The Mail order Survey

   ______% 

2. The Options Trade
   a. Would you buy the option? Yes / No
   b. Rate the quality of this trading opportunity:

   Poor ———— ———— ———— ———— ———— ———— ———— ———— ———— ————
   1 ———— 2 ———— 3 ———— 4 ———— 5 ———— 6 ———— 7 ———— 8 ———— 9 ———— 10 Excellent

3. The Quarterly Sales Estimate
   (Please record your estimate in millions of dollars.)

   $_________ million
SSN _______ - _________ - __________

**IMPORTANT:** Once you have started on this page, DO NOT make any changes to your answers on Answer Sheet #1.

Please refer to the **Mail Order Survey** page in order to complete these questions.

Below is a list of facts derived from the display. Please refer to the display and **RANK** the facts in order of their importance in your decision-making process. The most important fact should be ranked #1 and the least important should be ranked #5.

**RANK**

_____ 1. 80% of all adults report that they will order products by mail (BUYERS).

_____ 2. 20% of all adults claim that they never order products by mail (NONBUYERS).

_____ 3. Slightly less than 70% of all married couples share the same classification (both are BUYERS or both are NONBUYERS).

_____ 4. Slightly more than 30% of all couples are made up of one BUYER and one NONBUYER.

_____ 5. Mrs. X is a NONBUYER.

Below is a list of facts derived from the display. Please refer to the display and **RATE** the importance of each individual fact separately. Use the scale provided.

Not Important at All  1------2------3------4------5------6------7 Very Important

_____ 1. 80% of all adults report that they will order products by mail (BUYERS).

_____ 2. 20% of all adults claim that they never order products by mail (NONBUYERS).

_____ 3. Slightly less than 70% of all married couples share the same classification (both are BUYERS or both are NONBUYERS).

_____ 4. Slightly more than 30% of all couples are made up of one BUYER and one NONBUYER.

_____ 5. Mrs. X is a NONBUYER.
Decision Strategy Questionnaire

Please refer to the Quarterly Sales Estimation display (the bar chart) in order to answer this question.

Please read all of the possible decision strategies before choosing your answer. There is NO preferred answer to this question. It is important that you select that strategy which most closely matches the one that you utilized to solve the sales estimation problem.

Please circle the number corresponding to the decision strategy which most closely matches yours.

1. I chose a number at random between the highest and lowest numbers represented in the chart.

2. I selected a quarter from the past to use as a starting point and adjusted my estimate (up or down) from that point, based on the trend.

3. I used a mathematical formula to estimate the sales.

4. If none of the above strategies accurately describe how you solved the problem, please describe your method in your own words in the space provided.
Answer Sheet #4

SSN _______ - _______ - _______

Lawyer or Engineer?

What is the probability that John is a lawyer? _____%
APPENDIX G

TREATMENTS
Mail Order Survey

Studies of mail ordering tendencies have shown that 80% of adults of both sexes report that they will order products by mail, if only occasionally, whereas 20% claim that they never order by mail. Accordingly, people are classified by the marketing department as "BUYERS" or "NONBUYERS". In slightly less than 70% of all married couples, husband and wife share the same classification, i.e., both are BUYERS or both are NONBUYERS, whereas slightly more than 30% of couples are made up of one BUYER and one NONBUYER.

Mrs. X is a NONBUYER.

What do you think are the chances that her husband is also a NONBUYER?
Mail Order Survey

Studies of mail ordering tendencies have shown that 80% of adults of both sexes report that they will order products by mail, if only occasionally, whereas 20% claim that they never order by mail.

Accordingly, people are classified by the marketing department as "BUYERS" or "NONBUYERS". In slightly less than 70% of all married couples, husband and wife share the same classification, i.e., both are BUYERS or both are NONBUYERS, whereas slightly more than 30% of couples are made up of one BUYER and one NONBUYER.

Mrs. X is a NONBUYER.

What do you think are the chances that her husband is also a NONBUYER?
Mail Order Survey

BUYERS

NONBUYERS

Studies of mail ordering tendencies have shown that 80% of adults of both sexes report that they will order products by mail, if only occasionally, whereas 20% claim that they never order by mail. Accordingly, people are classified by the marketing department as "BUYERS" or "NONBUYERS". In slightly less than 70% of all married couples, husband and wife share the same classification, i.e., both are BUYERS or both are NONBUYERS, whereas slightly more than 30% of couples are made up of one BUYER and one NONBUYER.

Mrs. X is a NONBUYER.

What do you think are the chances that her husband is also a NONBUYER?
Options Trade

Assume that you are trading options for a commercial account. Your goal is to maximize the value of your portfolio. The current total account value of the portfolio is approximately $1 million. The total potential for loss in options trading is limited to the cost of the investment. The research department has identified a potential trade with the following characteristics:

Cost of the option: $20,000  
Potential return: $115,000  
Probability of losing is 80%.
Options Trade

Assume that you are trading options for a commercial account. Your goal is to maximize the value of your portfolio. The current total account value of the portfolio is approximately $1 million. The total potential for loss in options trading is limited to the cost of the investment. The research department has identified a potential trade with the following characteristics:

Cost of the option: $20,000
Potential return: $115,000
Probability of winning is 20%.
Assume that you are trading options for a commercial account. Your goal is to maximize the value of your portfolio. The current total account value of the portfolio is approximately $1 million. The total potential for loss in options trading is limited to the cost of the investment. The research department has identified a potential trade with the following characteristics:

- Cost of the option: $20,000
- Potential return: $115,000
- Probability of losing is 80%.
Options Trade

LOSE 80.0%
WIN 20.0%

Assume that you are trading options for a commercial account. Your goal is to maximize the value of your portfolio. The current total account value of the portfolio is approximately $1 million. The total potential for loss in options trading is limited to the cost of the investment. The research department has identified a potential trade with the following characteristics:

Cost of the option: $20,000
Potential return: $115,000
Probability of winning is 20%.
Quarterly Sales
(Millions)

What is your estimate for 3rd quarter 94 sales (millions)?
Quarterly Sales
(Millions)

Sales

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

What is your estimate for 3rd quarter 94 sales (millions)?
Lawyer or Engineer?

The following description is of a man selected at random from a group composed of 70 engineers and 30 lawyers.

John is a 30-year-old man. He is active in local politics. The hobby that he enjoys most is rare book collecting. He is competitive, argumentative and articulate.

80% of engineers are Republicans but only 50% of Lawyers are Republicans. John is a Republican.

What is the probability that John is a lawyer?
Lawyer or Engineer?

The following description is of a man selected at random from a group composed of 70 engineers and 30 lawyers.

John is a 30-year-old man. He is active in local politics. The hobby that he enjoys most is rare book collecting. He is competitive, argumentative and articulate.

80% of engineers are Republicans but only 50% of Lawyers are Republicans. John is a Republican.

What is the probability that John is a lawyer?
REFERENCES


Washburne, Jon N. "An Experimental Study of Various Graphic, Tabular and Textual Methods of Presenting Quantitative Material." The Journal of Educational Psychology 18.6 (September 1927): 361-376.


