Activity-Based Costing & Warm Fuzzies - -
Costing, Presentation & Framing Influences on Decision-Making
~ A Business Optimization Simulation ~

By

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Dissertation proposal submitted to the faculty of
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

BUSINESS
with a major in Accounting.

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April 8, 1998
Blacksburg, Virginia

Key Words: Activity-Based Costing, Computer Business Simulation, Decision Bias, Decision Making, Managerial Accounting, Presentation, Visualization

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(ABSTRACT)

Activity-Based Costing is presented in accounting text books as a costing system that can be used to make valuable managerial decisions. Accounting journals regularly report the successful implementations and benefits of activity-based costing systems for particular businesses. Little experimental or empirical evidence exists, however, that has demonstrated the benefits of activity-based costing under controlled conditions. Similarly, although case studies report conditions that may or may not favor activity-based costing decision making, controlled studies that measure the actual influence of those conditions on the usefulness of activity-based costing information are few.

This study looked at the decision usefulness of activity-based costing information under controlled, laboratory settings. An interactive computer simulation tested the ability of 48 accounting majors to optimize profits with and without activity-based costing information and tested to see if presentation format or decision framing would influence their outcomes.

The research showed that the activity-based costing information resulted in significantly better profitability decisions and required no additional time. Presentation in graphic (bar charts) or numeric (tabular reports) format did not influence profitability decisions but the graphs took longer for analysis and decision making. Decision framing influences were shown to beneficially affect profitability decisions but did not require additional time. Decision framing was especially helpful with the non-activity based costing information; it had no significant effect on activity-based costing performance.

This work is dedicated to Lynne.
We met and fell in love in 1966.

PREFACE

Once upon a time in a land called Brooklyn a man named Isaac Asimov was born. He grew up and wrote more books than anyone in the world. He said that writing a dissertation should be fun.

Kurt Vonnegut recently remarked at a talk at USC Aiken that the funniest thing he ever said was during a memorial service for Isaac. Kurt has said and written much during his career. Some fun, some not. He said that writing should be interesting.

My father said that my dissertation should be whatever I wanted it to be. He was like that.

Lynne, my wife and mate, said that my dissertation should be -- "DONE."

With that quadraphonic bastion of support and inspiration {hey Lynnie you're not in bad company here} I began. And, look and see, here it is: The Book!

Was it fun? Is it interesting? Is it what I wanted? Well we're a bit tired right now. Let's just say for now that all we really know for sure is that it is – DONE. And, as the pleasuring of one's wife is not to be taken lightly, the endeavor can be said to be at least in part a success.

Continued . .

Of course <u>concise--ituditivity</u> is not one of my particular traits (as is surely evidenced by this document). Many contributed to my efforts.

<u>Sincere appreciation to:</u>

Lynne -- You are my lucky star ~ thanks for the journey!

1. *With my father's love and support goes (without saying as it was always the two of them) my mother's love and support. She has always, does always, and will always love me and show her love in many ways. It is nice to be secure in such love.*
2. *My wife's mother, Dorothy Marie Pfretzschner Teti Werner, will be happy to see her name in a dissertation, and Isaac approves.*
3. *I thank my daughters. First I thank one daughter, in advance, for reading this book. She is certainly the only person not obligated to read it that will do so. Thank you.*
4. *I thank my other daughter for teaching me that all stories start with "Once upon a time." I have complied [and Isaac approves].*
5. *My grandchildren, because they are here [and on the way] to be thanked.*
6. *My sister from whom too many miles keep us apart.*
7. *I thank my committee chair for his support. Not only in this process, but since we first met at Virginia Tech he has gone out of his way to help me through the doctoral process. He has been a gentleman in the true sense of the word.*
8. *I had the best Dissertation Committee I could have had. They did their job perfectly.*
9. *My new home at USCA has supported and encouraged me as if I were family from day one. My thanks and gratitude are most sincere.*
10. *My Swedish fairy godmother, although he surely may not appreciate the title, has been there for me both in career and school. I should be so lucky that the clock never strikes midnight. (My wife calls this good karma, I call it good people.)*
11. *A military dining companion that observed "If you can't smell the borsht, it stinks!"*
12. *A friend from Colorado who wanted me to write about tigers -- sorry, but thanks for lots of other inspirations, smiles, and for always being there for me..*
13. *A Connecticut doctor that taught me to "Enjoy the Process." I will tell him, but he will never really understand how much that little advice has meant to me over the past few years.*
14. *For the memories.*

Special piece of mind tribute to: Frank, Kitty, Tony, Nat, and Ella for their lovely and much appreciated company throughout.

Lynnie, guess you'll be seeing more of me now . . .

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Chapter 1

Introduction

1.1 Warm Fuzzies!

Douglas Mook (1983) of the University of Virginia warns his audience: "Beware the Warm Fuzzies!" We conjure up images of innocent, soft-blue bubbles of happiness ominously transformed into a sea of overpowering perils. A Fantasia like scene from the Sorcerer's Den where once benevolent tools become enemies rather than allies. The scoundrel Mook speaks of is none other than "external validity." Yes, Mook counsels us against getting too cozy with, former comrade and champion of research methods, external validity. "The phrases external validity and external invalidity can serve as serious barriers to thought." (Mook, 1983). But how can such a valuable [warm fuzzy?] convention as external validity be anything but favorable?

Validity, according to Mook, is one of those sacred labels in the "warm fuzzy / good guy" camp, as opposed to invalidity, the "cold creepy / bad guy" stuff. He warns of the dangers of what he considers such inappropriate and casual labeling. Mook presents a very convincing case of how [warm fuzzy] external validity can seriously jeopardize the progress of science and how we are often better off without it.

This paper is not about external validity. It is about Activity-Based Costing (ABC). And we all know that ABC is a good thing. And that, is the point. Is it really, and is it always, under all circumstances? When it is good are there some circumstances or environments that make ABC "even better?" Should we consider that perhaps ABC carries some of the hasty and perhaps undeserved "good guy" labeling Mook cautions us against? This paper examines the "warm fuzziness" of ABC.

1.2 Activity-Based Costing

ABC is perhaps best defined simply as a means to more precisely explain overhead costs. ABC provides more precise overhead costing to desired cost objects. That is its goal. If overhead cost relationships are indeterminable, then ABC provides no value. Other, less meticulous assignment methods should be used or, some argue, no assignment at all should be made.

ABC fans get at least some empirical comfort through ABC's popularity among large U.S. companies[1]. Many of these companies praise the benefits their companies have received from ABC implementation. Anecdotally at least ABC seems to be a good thing!

Is it? Or, like scientific external validity, are there circumstances when the "warm fuzzies" of improved information[2] are simply not of value? Further, does the message media or message environment impact and influence the value of the ABC improved information?

Improved Accounting Information. This phrase strikes me as redundant. Accounting is, after all, information. It is the language of business results. Could everyday business environments not have practical use for information that is clearly superior and pertinent, such as ABC purports to be? Can superior information, under certain circumstances, result in detrimental business decisions?

This paper examines that question as well. Of course a more charitable phrasing of that same issue would be: "Are there conditions or environments that improve the usefulness of ABC information?"

1.3 Accounting Information & Media

We live in the age of information:[3] information networks, information highways, information period![4] As the capabilities and capacities of the information resources and presentation alternatives literally exploded, business management recognized that the accounting function could utilize these new resources to provide more and better managerial insights.

Accounting branched from the "How Much" functional area of reporting finite, past results to the "What If" arena of analytical and prospective issues. The "How Much" accountants served their audiences well with relatively straightforward numbers that told the desired stories. As the nature of accounting information sought evolved, however, the message became more complicated. The "What If" questions covered more ground, had more directions to pursue. Simultaneously emerging computer technologies in graphics and other

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[1] As evidence of the popularity of ABC, a search of the ABI database in March 1995 showed that from January 1990 through February 1995 there were 547 references to business magazine and journal articles on ABC. That works out to about nine articles per month. The vast majority were favorable testaments to the attributes of ABC. Furthermore all six of the Big Six accounting firms, plus countless other consulting firms all either have or actively sell ABC software and their ABC consulting expertise.

[2] Understand, I refer only to cases where we know that the ABC cost information is accurate [meaning it provides more precise cost information] and is relevant. This paper studies the value of ABC information given that it is both (1) accurate and (2) relevant.

[3] Interestingly, my computer tells me that a synonym for information is intelligence. My dictionary of the "pre-computer" era mentions nothing about intelligence.

[4] It appears that the dynamic, creative and leading edge of accounting lies with information systems. In fact the informational system track of accounting is perceived as so important that it is strangely acceptable for [systems] accounting faculty at major universities not to know any accounting!

areas provided a virtual explosion of media and communications options to meet these changing needs.

Computer graphics put more alternatives at the accountant's literal fingertips than accountants have the time to explore. Certainly there is a limit to computer assisted communications media. But we will not approach this limit for some time. Current display research centers on three-dimensional imaging. Virtual reality for accounting applications may seem like the proverbial too much of a good thing, but who knows the practical limits that improved communications may bring?

The point is that recent growth in graphics has been exponential. This growth has afforded the managerial side of accounting a welcome opportunity to improve its message and reach a wider audience. The explicit objective of this facilitated managerial message is improved decisions, improved operations, and improved profits.

These new communication options are available at low cost and they are easy to learn and apply. Internet resources have further expanded both the source of information available to the managerial accountant and the presentation/communication alternatives. Importantly, the Internet and the new software have also done much to increase the user's expectancy for communications that are effective, easy to use, and pleasurable. Yes, pleasurable - - the audience is now accustomed to not only receiving the relevant information, but now has some level of professional presentation expectations.

These two recent events, first the nature of the information desired, and second the growth in communication alternatives available combine to provide exciting opportunities for accountants. Information itself has no value; communicated information has value. This process is made most efficient when the communication paths are 'greased.' In this case the grease is media presentation. The presentation should be clear, provide the least cognitive resistance and should be entertaining to the user. The entertainment factor plays to the competing demands on user time. Without the entertainment or packaging factor the message may be perfect and accurate, but it is as the falling tree in the woods -- no one hears it. Therefore it has no value. Value is the point of interest here; accuracy is presumed.

Users of the "How Much" accounting information were happy with the numbers. The numbers spoke for themselves. Their messages were clear. Unlike the "How Much" information, however, the goal of the newer 'analytic' accounting information is not to count money, but to make it.

Graphics software companies are marketing versatile and inexpensive products that they claim fit this information packaging goal. These companies claim graphics will improve decision speed and decision accuracy. Generally the graphics are attractive. They are designed to give efficient transfer of information, to enhance user satisfaction and, yes, to be pleasurable to use as well. Software company claims notwithstanding, the superiority of graphics remains open to challenge; graphics are not universally advantageous in all decision environments. Further, presentation attractiveness and user enjoyment, although seemingly worthy message enhancements, are similarly empirically unsupported as decision facilitators.

1.4 Research Expectations & Experimental Design Introductory

> **The purpose of this research is to investigate (1) how certain analytic accounting information [specifically ABC] affects decision making and (2) how that decision making is affected by the communication media and the message environment.**

Activity-Based Costing is used as a 'platform' for the decision making model. Profit-oriented business decisions are examined with and without ABC and with and without other environmental factors. In a small way the research may be generalizable to ABC business environments. As Mook (1983) warns, however, such specific generalization is perhaps only a distraction to the less generalizable, but explicitly desired results of this research. This research is a controlled study of selected cognitive influences on decision making

The value of ABC in this study is defined by the specific decision usefulness of its information. Decision usefulness, normally difficult to quantify, is defined by results. The results are dollars of decision generated profits. This is very measurable. The important distinction here is that the accuracy of the ABC information is not in question. It is accurate. That is not the issue. It is the usefulness of the ABC information that is the focus of this study. Usefulness is hypothesized to be affected by factors external to information content. The value of information is empirically [and conveniently] defined by a very objective and practical criterion, profits. Profits define the value or usefulness of information, and usefulness is central to the purpose of this study.

Media and cognitive environments are examined with respect to the value of ABC information in decision making. This research hopes to identify possible conditions that may act as barriers to the utilization of superior information, or to identify conditions under which superior information might be pernicious. By so doing, conditions favorable to efficient information utilization should be evident.

As accounting continues in the business of information transfer, the value of the information will not be in its retrieval, nor even in its inherent level of accuracy. Accurate information will be expected, and plentiful. Value will rest in [accurate] information that is: (1) pertinent and useful, and (2) effectively communicated. Time, relevancy and communications efficiency become the restraints of interest.

I have chosen three interactive factors to research in this context: (1) information content/complexity, (2) presentation, and (3) decision bias. Content, operationalized as ABC & non-ABC, has intuitive and theoretical connections with both presentation and decision bias. The theoretical inter-relationships plus the prevalence of these three factors in real business decision environments is the reason that these three factors were chosen. That content can be easily and realistically operationalized as ABC adds to the attractiveness of the research. Although the controlled context in which these factors will be examined precludes direct generalization to the business decision environment, knowledge of the behavior of these factors and their interactions should add to understanding of the fundamental decision making processes.

Factors two and three are presentation and framing bias. Presentation is operationalized as one of two formats: graphic or tabular. Framing bias is defined in the study as a means to provide additional focus or direction in the decision making process. All three factors and their operationalizations as discussed in detail in the body of this paper.

Several possibilities exist for response variables. The obvious focal point of any decision research study is accuracy of decisions. In a business situation the quality of decisions is generally ultimately manifested in change in profits. Profits achieved is considered the primary response variable of interest in this study. Other choices might include time taken to reach decisions, ability to identify trends or variable relationships and finally user preference or decision confidence. Comprehension of data or recall might be of interest as well. Rather than explore too many issues I measure decision time as a second response variable and leave the others to future studies.

As discussed in depth in Chapter 2, previous work in cognitive receptiveness forms the foundation upon which this study builds. This study focuses on the interactions of the previously studied conditions, but the main effect replications are equally important. The main effects have been researched, but in different contexts than I investigated. The questions of interest for this research are (1) what new main effect nuances will surface that might add to previously studied results and (2) under what combination of conditions is information best assimilated? (Conversely, are there combinations of conditions that may dilute or reverse the benefits of improved information?)

Hypothesized interrelationships are investigated using mixed factor ANOVA and MANOVA experimental designs. Covariate relationships involving possible correlation with SAT scores, grades, spatial skills, college major, sex and other factors are also considered. This experiment tests decision-making effectiveness and problem solving abilities under varying levels of information content/complexity, presentation and bias. The dependent variables are: (1) performance and (2) time. Performance is measured in dollars of profits. Time is defined as the time required to make decisions.

The experimental design incorporates the advantages of control and statistical sensitivity afforded by repeated measures designs for the presentation and decision bias factors. Sequencing of these factors is completely counter-balanced. Prompt saturation of learning effects limits confounding by same subject repeated trials. The content/complexity factor uses a between subjects, nested design. An interactive computer model was used to present simplistic economic profit maximization simulations to subjects under varying experimental conditions. Results were computer generated as well.

1.5 Background: Activity-Based Costing Backlash

Activity-Based Costing inspired this research. Accordingly ABC deserves discussion. It is an innovative, interesting, and valuable[5] decision tool. This research does not focus on ABC as a system, managerial tool, or even as an issue. Rather, it presumes ABC has value. The research questions, however, the efficacy of that value under certain common decision making conditions. Decision making issues are examined under experimental conditions.

That the U.S. managerial accounting profession has made a valuable and substantive contribution to strategic management practices over the past ten years is evident by abundant business articles and consulting activities that all center on this recent phenomenon, Activity-Based Costing [again, footnote 1 evidences its popularity]. "Activity-Based Costing is clearly the most significant managerial accounting development within the last fifty years." (Harrison & Sullivan, 1996). Just as American business was getting comfortable with a sense of renewed self-assurance and confidence, however, ABC and its extension ABM (Activity Based Management) have generated some disturbing criticisms.

First, the purported value of ABC and ABM is improved decision making, resulting from improved and more precise decision making information. And information is the business of accounting. "The essence of accounting is the communication of financial and managerial information." (Johnson, Killough & Schulman, 1995). Few argue with the premise that ABC does provide more precise cost information. Business managers and engineers seem to continue to endorse that ABC premise; it makes sense!

There are those that argue that ABC, although effective in better defining costs, does not necessarily contribute to the overall effectiveness of business decisions. They argue that ABC information may be irrelevant and serve to detract from what are the key elements of certain decisions. Others argue that the enhanced precision in defining overhead allocations is not as accurate as most users believe. Users gain a false sense of unjustified confidence in ABC supported decisions, abandon previous [successful] decision frameworks and arrive at weak decisions, they say. There are other normative and deductive positions on both sides of the issue.

In spite of the abundance of generally favorable ABC literature as evidenced in footnote 1, there has been very little research that challenges the merits of ABC from an empirical or experimental perspective. That is to say that the literature may be overwhelmingly favorable in terms of individual business testimonials and research oriented case studies that document ABC utilization, but market valuation studies that might show empirical evidence that ABC has favorable business effects have not been done. Similarly, although ABC can clearly be shown to provide more precise costing information, it has not been demonstrated in a controlled experimental environment that ABC information in fact leads to more profitable managerial decisions.

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[5] Analytically and certainly anecdotally ABC has proven very valuable to many businesses. See favorable attestations in footnote #1.

At a recent academic, managerial conference (Management Accounting Research Conference, October 1995), some attendees argued that the value of ABC has yet to be subjected to the statistical, empirical rigors that necessitate academic survival. That is, yes, undeniably ABC offers more precise cost information; the question is, however, so what? The connection between ABC and profits has yet to have been established[6].

In 1992 Thomas Johnson warned that "I believe it [ABC] has gone too far. It should be redirected and slowed down, if not stopped altogether." Peculiar counsel from the person who was a "co-founder" of ABC. His book, co-authored with Robert Kaplan, Relevance Lost, (1987) paved the way for the ABC and to some extent made possible ABC's success.

Meanwhile, curiously and somewhat to the chagrin of ABC enthusiasts, the Japanese have never endorsed ABC. The abundant managerial contributions from the Japanese conspicuously omit reference to America's singular, recent significant contribution, ABC. There is evidence that the Japanese employ ABC-like analyses in target costing, yet there is no evidence that ABC is employed more universally as a cost system or for strategic decisions. Hiromoto (1988) states that the Japanese focus on "reducing direct labor ... for ongoing cost improvement." He says Japanese believe that direct labor control is the key to all cost control efforts. By tying overhead allocations to direct labor, rightly or wrongly, management is forced to focus on labor. This approach, focus on labor and you will achieve your overhead goals, is in direct contrast with ABC[7] that invites direct investigation of overhead.

This study investigates a small aspect of the ABC question. ABC clearly provides more accurate managerial cost information. Yet, if the ultimate value of that more precise ABC information is being called into question, then one might logically challenge two aspects of that ABC information: (1) the relevancy of the ABC information for decision optimization and (2) the usefulness or "friendliness" of the ABC information.

This research concentrates on the second, information usefulness issue. Presuming precision and relevancy[8], the conditions that may favor or disfavor information usefulness are explored in an experimental setting. Insights into decision making in general and ABC decisions in particular are certainly desired, however. Given more understanding of the decision making processes, the question of ABC's value may then be more intelligently and empirically pursued. The generalized research question is:

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6 An empirical investigation of the truly pivotal ABC research question, whether ABC usage adds value to the firm, remains elusive. Technical hurdles seem to preclude performance of such a study, as yet. [It is, however, on my list.]

7 Turk reports in the "Journal of Cost Management" (Winter 1990) that Harley-Davidson has abandon tracking direct labor as a separate component of cost. They determined that direct labor was about 10% of product cost (vs. material of 54% and overhead of 36%) but required over half of the cost accounting efforts to track.

8 Accounting texts consistently illustrate the precision of ABC information; the business literature provides support, although admittedly not proof, for the relevancy issue. See note 5.

1. *Do certain decision environments affect the usefulness of [ABC] information?*

~ ~ or ~ ~

2. *Can information usefulness [value] be improved?*

CHAPTER 2

THEORY, LITERATURE REVIEW & HYPOTHESES

2.1 Theory

This research centers on human information processing, decision-making. The decision-usefulness of information is challenged under three distinct but cognitively interrelated conditions: information content (ABC), presentation format, and framing bias. ABC is the platform for the study, and ABC is the essence of the underlying issues that motivate this line of study. Decision making behavior, however, is the explicit subject of the research. ABC is purposefully used as the decision setting, but the theory examined is fundamental to the much wider decision-processing domain. ABC serves as a very welcome proxy for the information content factor of interest. In this context, the interactions with the other two factors are of most interest when combined with the ABC factor.

In summary, while the research objective of the study is decision oriented, ABC applications in the business world inspired the research and ABC is used to ground the theoretic issues to the business and accounting area. The other two decision factors of interest in the study were selected because they were (1) fundamental to decision theory and (2) specifically relevant to ABC in the business world.

Decision performance as it relates to these three factors is what drives the study. Performance has perhaps several facets of interest. The two most obvious and certainly two of the most important from a practical perspective are very simple and [fortunately] very measurable: decision quality and time. The two are also inter-related; decision quality (profitability) is affected by decision time taken. And decision time is affected by the quality of decisions made. Simply put these two response variables often have an inverse relationship to one another in terms of their desired outcomes [high quality, low time].

The following sections introduce relevant research findings for each of the three conditions studied. These introductory sections form a chronology that leads to the development of the research questions and hypotheses. Discussion of the hypotheses includes theoretic support that is tied back to the introductory research.

2.1.1 Content, Complexity and Cognitive Fit

Operationalized as ABC information versus VBC information (traditional, volume based costing), content/complexity is the factor of interest. The experimental design mimics reality by presenting ABC decision information that is more accurate[9] than its counterpart VBC information. On a practical level, in the business world, ABC information will have degrees of accuracy and degrees of relevancy. In a textbook setting ABC is clearly more accurate and relevant than VBC. That is the objective and definition of ABC. I have designed the ABC experimental condition exactly so as well; ABC overhead costing information provides more precise cost information to the experimental participants.

Behaviorally, ABC information is more complex information to process. ABC presents the user with more cost information. That in itself introduces an additional level of complexity. Next, each element of ABC information is derived from a relevant basis [its cost driver]. This ABC / cost driver relationship, although usually fundamentally simple, introduces further complexity into costing. The user has a natural inclination to want to understand and be comfortable with the relationship between cost driver and cost. VBC costing is singular and presented as a calculated fact. The VBC calculation requires math only, it is not necessarily logically tied to its basis as its ABC relations are. Accordingly, the experimental model establishes the ABC factor as more precise and more complex decision information. Whether it is useful as defined by decision performance, and under what additional conditions is it more or less useful, are the research questions of interest.

As is true in real business environments and perhaps life in general, quality carries a price. ABC may be costly to the user in that its precision necessitates a level of complexity that does not accompany the less precise VBC information. This price of ABC quality may manifest itself in both response variables: decision accuracy and timeliness.

Business text illustrations have convincingly demonstrated that ABC methods provide information appropriate for optimization[10]. Field studies noting successful ABC results are similarly abundantly reported in both academic and industry journals[11]. Academic journals also report empirical evidence of ABC superiority in problem solving and optimization simulations (Mishra, 1996; Berg and Sprinkle, 1995; Harris, 1993). Clearly ABC has demonstrative advantages.

For the sake of argument consider that at least in some circumstances more information, regardless of its superiority, will at some point impede progress: advantage becomes disadvantage. Daylight illuminates our field of vision, provides more visual information, improves depth perception; we drive better with more light. But clearly there is a limit. Too much light can be disastrous. Likewise, information, even relevant, accurate information may be beneficial only up to some limit. The expression “Don’t bother me with the facts, I have to make a decision” may have more relevance than some care to acknowledge. Has accounting based capital markets research shown that additional financial reporting and disclosure irrevocably improves investor performance, or even affects market pricing? My

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[9] Accuracy in cost information: the cost object and the cost driver have a direct, quantifiable, and reported relationship.

[10] Horngren, Foster, and Datar (1997) for example, give very detailed demonstrations of the superiority of ABC in analytical, profit-oriented decision making in two chapters of their most recent cost accounting text.

[11] See note 1 and Chapter 5 .

premise is that quantity and even quality of information are not necessarily the primary factors governing effective decision making, especially in decisions that are clouded with competing influences.

For example, Vessey has done interesting research (1991 & 1994) on decision making and cognitive information processing. She defines levels of “cognitive fit” that match presentation and task. She believes that regardless of the proven relevancy and accuracy of certain information, under some circumstances such information may impede successful task completion. Again, calculus may precisely enable users to determine exact rates of change, but some users may more accurately predict changes with more simple math or with graphs. In another context, it takes extremely sophisticated computer programming to identify relatively simple three dimensional representations. The human eye identifies such representations immediately; additional computer analysis no matter how much additional and precisely accurate information it provides adds little value. It is a distraction.

Vessey (1994) uses task specific explanations to classify users as spatially or symbolically oriented and interprets problem solving results according to these task orientations. As additional factors are introduced into problem solving environments, however, internal cognitive classification and prediction become complex issues themselves. For example some users may be spatially oriented for certain tasks, but as the environment takes on dynamic characteristics those very same users may develop problems with spatial solutions.

This is a significant point. In the absence of additional influences problem solving is facilitated when represented in a particular task related set. Add complexity, however, and optimal solution representations may shift entirely to another format. Experimentally this behavior is represented by the interaction of the conditions studied.

The questions of relevancy and complexity for ABC information can become issues that may hinder instead of help problem solution. Optimization decision frameworks and their corresponding mental representations or cognitive fits change as additional factors affect the usefulness of the information. The information and problem may be static, but if the decision environment is dynamic, completely different results may occur.

Cognitive problem solving involves stages of problem representation that are transformed into a mental representation before the mind engages in the final problem solving task (Vessey 1991). Importantly, mental representation and problem solving are considered independent activities. Interference with the first, mental representation stage will affect the second and primary process of interest, problem solving. Interacting conditions, such as initial decision framing and the task suitability of presentation, will accordingly provide differing levels of interference in mental representation and affect problem solving accordingly.

Beach and Mitchell (1978) and Payne (1982) have researched a “cognitive cost-benefit” behavioral model that indicated that trade-off’s exist between representation and problem solution. Christ and Vessey (1994) have extended this work, concluding that “decision makers change strategy [decisions] to accommodate even minor variations in the task.”

In the financial area work has been performed researching decision making for bankruptcy prediction and auditor “going concern” judgments. In reviewing this research, Christ & Vessey (1994) concluded that as the amount of information available to the decision maker increased, the added complexity ultimately resulted in diminished analytical judgment. Precision of mental representations necessary for accurate problem solution is enhanced by relevant information but simultaneously harmed by the “cost” of added complexity.

Additional information, no matter how relevant, comes with a cost. In economic jargon, there are diminishing marginal returns. Even completely relevant information contributes, at some point, less value than it costs. The practical cost of producing the information notwithstanding, the cost of interest here is the cost of added complexity to the decision environment itself. And that complexity is said to diminish performance accuracy and increase the time required for solution.

The question is: does the relevancy of the additional information offered by ABC offset the additional complexity introduced to the problem? If, as in the case of some manufacturing environments, the marginal relevancy contributed by additional ABC information is not significant, then theory holds that problem solving accuracy will suffer. The cognitive cost of the additional information is not offset by its relevant value. The importance of information relevancy is again emphasized. Additional information, relevant or not, is not an insignificant “noise” factor that can be ignored as extraneous or inconsequential.

This research experimentally presents subjects with information sufficient for making optimal decisions under all conditions. The quality and relevancy of the information is superior in ABC format, but it is more complex. Complexity is operationalized by including detailed ABC cost information. VBC costs contain three simple cost inputs, direct material, direct labor and total overhead. ABC includes six overheads costs, a total overhead amount plus the two direct cost items. Plus, as noted above, ABC injects a further level of complexity. The ABC cost information represents logically consistent cost behaviors. VBC cost information is merely there as a calculated fact. The logical ABC cost relationships invite thought.

Introduction of other research factors of interest (presentation and bias) further complicate the decision environment. According to theory, the additional information carries a price in complexity or simply additional information that will affect the accuracy of the mental representation necessary for problem solution. Measurement of these effects on decision making is the essence of this research. the specific question is whether the more precise ABC information conveys more or less value in combination with other factors.

The research plan here is very delicate. Ideally the ABC content factor will be created such that as a main effect it will be favorable to decision performance. In the presence of the other research factors, however, the research design is directed at eliciting an interaction such that the “ABC advantage” has measurably different effects on decision performance. The “ABC advantage” will not necessarily go away, nor become disadvantage. But it is anticipated that in the presence of the other conditions the ABC influence will become significantly different than when measured as an individual effect.

2.1.2 Presentation & Visualization

The literature on presentation issues is extensive. I have selected the following research to comment upon based on two criteria: (1) it most directly relates to my applied, business research interests and (2) it follows a chronology that contributed to current theories. Following a brief introduction below, this section starts with a summary of related research findings through 1984 upon which DeSanctis reported (1984). Her summary is used as a preliminary focal point. It shows that the studies up through 1984 lacked a strong theory-driven basis and were substantially inconclusive. Following DeSanctis’ summary I trace through fourteen subsequent studies that moved the research forward to 1991. In 1991 Vessey prepared a summarized research report and used this as a basis to codify relevant theory. I use Vessey’s research framework and her model of cognitive fit to combine the presentation and content issues relevant to my research. This model also incorporates the final factor in my research, decision framing. All three factors form the basis for my hypotheses that are discussed in the final section of this chapter.

Simon (1975 & 1981), Libby (1981), Ashton et al. (1988), Remus (1984), Perrig and Kintsch (1985), Kleinmuntz and Schkade (1993), DeSanctis (1984, 1885, 1986, 1989), Jarvenpaa (1989), Davis (1989), Anderson and Reckers (1992), MacKay and Villarreal (1987), Vessey (1991 & 1994), Benbasat (1985 & 1986) and many more are among those who have studied the graphical versus tabular effectiveness of information presentation.

Researchers in presentation format effectiveness often refer to their work as “Tables & Graphs” studies. The issue is not which is more accurate, but which conveys usable information most effectively. More to the point, which media results in the best decision in the least amount of time [effectiveness and efficiency]? This theme is to some as interesting and endlessly debatable as the famous “Genetics & Environment” quandary. Fortunately the Graphs & Tables dilemma is conveniently measurable. Unfortunately, those measurable results, to date, give conflicting answers.

Researchers have investigated both generalized cognitive presentation issues and specific business applications. The business studies tested whether graphical information conveyed relevant information more effectively than tabular presentation. As business decisions are generally analytically supported with relevant “numbers” and the results of the decisions [business performance] are almost always measured in numbers, these studies are appealing. And as accountants are the “keepers of the numbers” feedback on effectiveness of presentation is critical to accounting usefulness. Here I am back to the definition of value in terms of usefulness and communicability. To be valuable accounting information needs to be more than correct. It needs to be correct and communicated. Effective communication improves value.

While some studies draw definitive conclusions about the superiority of certain presentation modes, as a whole the body of literature on the subject is inconclusive. "The literature appears to have arrived at few conclusions with regard to the performance of the two representations [graphs vs. tables]." (Vessey, 1991). Even within studies consistent conclusions are often absent: "Our results suggest that the relative contribution of graphic displays to decision making may vary considerably from situation to situation." (MacKay and Villarreal, 1987).

In 1984 DeSanctis summarized the significant "Tables vs. Graphs" research to date. The following shows that of 29 studies DeSanctis reviewed, slightly over a third favored tables, slightly under a third favored graphs and the remaining third were inconclusive:

TABLE 2.1

SUMMARY OF RESEARCH RESULTS COMPARING GRAPHS AND TABLES

Dependent Variable	Better With Graphs	Better With Tables	No Difference
Interpretation accuracy	2	4	1
Interpretation speed	1	1	--
Decision-making or problem-solving quality	1	3	3
Decision-making or problem-solving speed	1	1	2
Information recall	--	--	2
Preference	2	2	--
Decision-making confidence	--	1	2
Total	7	12	10

I believe that the inability of researchers to provide move persuasive conclusions include the following:

- Individualized characteristics of the audience itself may impact message communicability more than format. For example, spatial abilities may make graphs more friendly for some users and less friendly for others.

- The issue is more complicated than can be generalized to simplistic preferences that will hold across all conditions. Note that several studies showed communicability to be significantly better under certain conditions, but not others. For generalizations to hold beyond the conditions of the studies themselves deeper understanding of the mental processes was required than the research studies in question pursued.

- Presentation efficacy may be task-dependent. Strongly analytic tasks may favor tables; some simple data inquiry tasks may favor graphs. Conversely, a certain type of analytical thinking such as trend analysis, may specifically favor graphs.

- Time may be a variable that needs to be controlled. Graphs may be faster, but less accurate. Thus, under timed conditions graphs may outperform tables, but without this constraint tables may be better.

- In their quest for a simplistic answer to a seemingly dichotomous and seemingly simple research question (which performs better) underlying theory was often bypassed in favor of strictly results-oriented approaches. Thus specific findings, and inconclusive results provided little opportunity to build upon each other.

This is a complicated issue, not amenable to casual generalization. The conditions favoring one media over another is far from apparent. Confounding issues were identified in some research as task-related, some as individual user dependent, some varied with time constraints, and certainly some remained unknown. Further, as one might suspect, the confounds became interactive factors. Experimental situations were often affected by uncontrolled factors including the interactions between task, users, and other conditions. It would be convenient if simple presentation generalizations were discovered, as yet simplistic solutions remain elusive.

Much early research was results-driven and bypassed theory development. A clear research direction failed to emerge from such exploratory examinations. These contradictory results were caused because the human issue was not the simple table/graph experimental issue but one of human cognition. Bottom-lined empirical research could give persuasive results in some experimental settings but did not provide a decision model basis for future development. For simplistic issues such a bottom-lined orientation was satisfactory, but human cognition is far from simplistic.

The most conclusive research came from researchers that attempted to theorize about why one form of presentation (e.g. graphic) may be superior to another. In later research theory-based work did develop. Recently researchers have coupled theory with well defined and theory supported expectations (dependent variables), which provides valuable insight.

Below is a chronology of relevant research subsequent to 1984. As a prelude to relevant theory development, however, perhaps one should start with the simple presentation observation made by Washrurne in 1927. He concluded that users were more accurate in identifying specific values from tables but identified data trends better from graphs. Between 1927 and 1984 certainly much more work was done. As noted above, however, theoretic conclusions beyond Washburne's results-driven observations was sporadic. A major step in theory development was summarization of nine premises by DeSanctis (1984) from her review of relevant presentation format research:

<u>Premise 1:</u> *Practical guidelines on graph selection remains elusive because of conflicting research results and a lack of systematic effort in the research.*

Premise 2: *Color may increase attention, but does not necessarily improve comprehension or task performance.*

Premise 3: *People prefer, and will better remember, visuals that are realistic; but realism does not improve comprehension.*

Premise 4: *Simple graphs are more easily understood.*

Premise 5: *Communication effectiveness studies between graphs and tables give conflicting results.*

Premise 6: *Preliminary evidence suggests that graphs are no better than tables in presenting information.*

Premise 7: *The best method of data display may be task dependent.*

Premise 8: *The ability to use graphs effectively varies across individuals.*

Premise 9: *There is speculation, but no empirical evidence, that user training improves comprehension of graphs.*

While some of the above are self-evident, and none are really conclusive in terms of providing much evidential guidance in developing presentation and communication protocols, this was a valuable summary of progress in the area through 1984. Premise #6 restates the disappointing results in the basic graphs and tables dilemma. The inconclusive findings explained why on a practical level presentation prescriptions were ineffectual and supported the need for further study. DeSanctis (1984) recommended that future presentation research use the following general framework to wash some of the inconclusiveness from the graphics-supported decision aid issues:

" A FRAMEWORK FOR RESEARCH ON THE USE OF GRAPHICS AS DECISON AI **DeSantis, 1984**

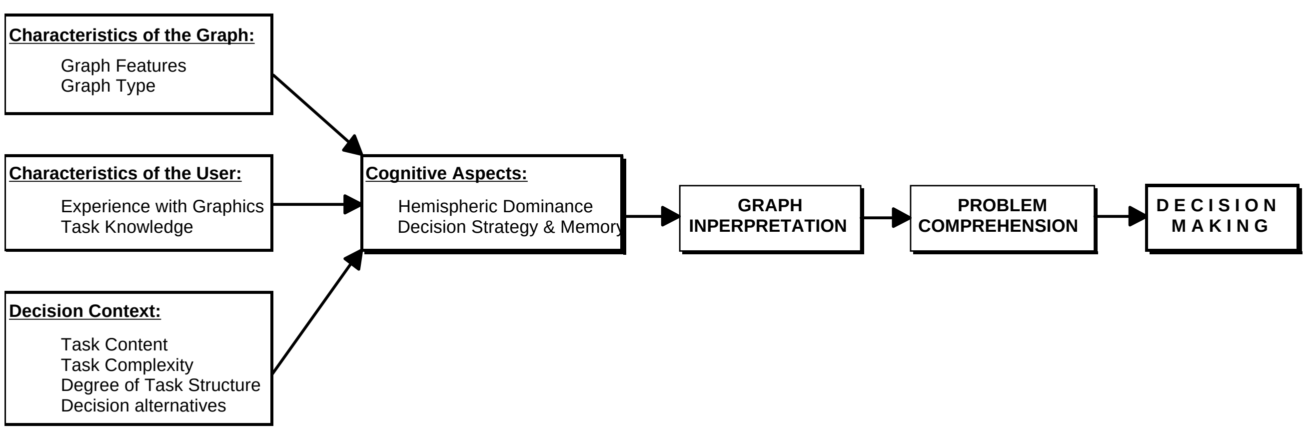

FIGURE 2.1 DESANCTIS RESEARCH FRAMEWORK

Since 1984 the interest in graphics leveled somewhat. This leveling of research interest is a little surprising, especially in light of all the advances made in the late 1980's in more accommodating software and the exponential increase in users. This leveling was perhaps a result of simple research frustration brought on by conflicting and non-significant findings. Research and theory development certainly progressed but were outpaced by technology advances and expansion of the core of applied users.

DeSanctis (1985,1986,1989) and others, notably Benbasat (1985,1986), Jarvenpaa (1989,1989) and Vessey (1991,1994,1994,1995) have in fact moved the research along very favorably since 1984. The more successful studies have included theory-driven approaches, and a reasonable line of theoretic conclusions have emerged. Notwithstanding these contributions, an understanding of the basic graphs vs. tables issue remains obscure. The quest for clear presentation guidelines that can be put to practical use continues to provide plenty of challenge.

In 1991 Vessey published a summarized research article similar to DeSanctis' 1984 summary. Vessey's review concluded "to date, however, the literature appears to have arrived at few conclusions with regard to the performance of the two representations [tables & graphs]." Vessey analyzed the research through 1991 from a cognitive fit perspective. This approach yielded some consistent explanatory patterns. She noted that when tasks were categorized into spatial [graphic] or symbolic [tabular] groups performance was enhanced when cognitive fit was realized between the task type and presentation mode. I believe this represented a significant conclusion and step forward in the research stream.[12]

Vessey's conclusions were limited to "information acquisition and simple information evaluation tasks" (1991, p. 219). This left deeper analytical tasks unsubstantiated, but still represented welcome progress in making sense of otherwise conflicting research. (Re: DeSanctis (1984) and the 29 studies that seemed to be one third table preferred, one third graphic preferred and one third neither). Vessey's analysis was also restricted to conclusions from existing research. Her conclusions also could not consider individual user preferences or abilities, which seemingly would have at least some interacting effects.

I will come back to Vessey's theory based explanations later (Section 2.1.2.1) , but to better appreciate her work and to understand the chronology of research progress between DeSanctis' 1984 literature review and Vessey's 1991 summary I have briefly summarized significant related research finding below:

1. In 1984 Remus looked at the graphs and tables dilemma in a more analytical decision mode than most studies (prior or subsequent). Remus was frustrated by lack of consistent results for either graphs or tables. He approached the problem by using a more complicated

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[12] Vessey was not the first to use cognitive fit to explain results. But I do believe that her use of such theory applied to prior research in her "status of the research" article provided fruitful direction for future research.

research setting than most prior studies had employed. Remus had subjects participate in an optimization simulation. The simulation included an uncertain demand function and cost functions that were both linear and quadratic. Results remained inconclusive under most of his experimental conditions. Only when the error variance in the simulations was reduced by what he described as the composite rule (Bowman [1963] and Hamner and Carter [1975] techniques to remove some of the error variance from experimental data) did the tabular results appear to be superior. Remus concluded that the erratic components of decision making disguised the benefits of the tabular aids. (1984, p. 540). This study is important in that it used a relatively complex setting to examine decision making. Its basically inconclusive results support Vessey's (1991) later cognitive fit work that indicates that the more complex and analytical a task is, the less likely it is that graphic or tabular superiority can be demonstrated in a straightforward manner.

2. Stock, Collin and Watson (1984) used imagery to represent graphics and compared the ability to detect changes in financial condition between subjects using images and subjects using standard tabular data. The images used were simple drawings of human faces. This was an interesting application of graphics as the use of faces eliminated any numerical grounding whatsoever for participants. Forecasting was based purely on the extent to which individuals could detect nuances in the images presented. Stock et al. theorized that the subjects would be able to code pertinent information in an associative structure using the graphics and that "recall cues can be linked to the associative structure by using imagery tied to the graphic." Also that "a linkage between the associative structure and recall cues all facilitate human information processing... that humans can more easily learn how to use multidimensional graphics than tabular presentations." (1984 p. 193). Interestingly, even across experience levels, subjects were better at detecting financial status changes using the pictorial images than by using tabular data. It was of interest to note that although more accurate, the graphics did not result in any time savings over tabular analyses. One suspects that had line graphs or other trend sensitive displays been used the graphics would have performed even better. It fits, however, with Vessey's 1991 cognitive fit theory that graphic information is best suited to simple analytical tasks as opposed to the superiority of tabular display for extracting and reporting discrete data.

3. Jarvenpaa, Dickson, and DeSanctis (1985) reviewed several graphs and tables experiments and then went on to describe their frustrations in controlling for internal validity issues in a series of three experiments of their own. Actually they planned on only one experiment, but after unsatisfactory results they redesigned their study to compensate for some problems they encountered, only to find more problems, which led to a third experiment. Their work is largely a case study that demonstrates the need for specific controls in pursuing this line of research. Most of the problems encountered with the three experiments were noted to be task and problem definition related. They used a complex case study approach. They reluctantly concluded that "obviously the task was not producing the basis for answering our research question of the relationships among task, presentation format and decision performance." (1985, p. 150).

4. Benbasat and Dexter (1985) found no differences in performance of their experimental tasks between graphic and tabular presentation. They did find user preferences that varied with tasks, but decision making precision was indifferent to presentation mode. They concluded that "proponents of graphical presentation must qualify their claims to environments where there is a clearly defined rationale for the benefits [of graphics]." (1985, p. 1348).

5. Dickson, DeSanctis and McBride (1986) added to the research stream in two ways. First, they ran three experiments using 840 subjects. With such power one would presume that if differences existed between tables and graphs, significance would surely surface. Although some differences were noted, in general no persuasive conclusions vis-a-vis the superiority of graphs or tables could be generalized. "The program of cumulative experiments indicates that generalized claims of superiority of graphic presentations are unsupported, at least for decision-related activities." (1986, p. 40). They did surmise that presentation seemed to be a function of the tasks performed and was situationally dependent. Again this is consistent with Vessey's 1991 conclusions.

Their work presented a compelling argument for the applicability of students in presentation research especially in what they termed "exploratory theory building." They maintained that task dependent research was related to cognitive processes that is common to humans irrespective of experience.

6. In 1986 Benbasat and Dexter returned with interesting studies that focused on interactive effects of presentation. Color and time constraints were added as variables to note their influence on graphic and tabular performance. In addition to decision precision, user preferences were included as dependent variables. Although some might feel preference is not outcome related in terms of performance, in actual practice users that find presentations attractive might pay more attention to analytical tasks and ultimately perform better. Intuitively this reasoning is perhaps even stronger for realistic, non-experimental presentation conditions. As I mentioned previously the significant advances in communications include the ability to captivate and entertain the audience. With the explosion in communications this "entertainment" factor, I believe, becomes more and more important. Information actively competes for the time of its audience. The better it can package itself the more productive it is, the more value it has and the better will be the decision outcomes.

Color was found to aid decision precision under tighter time constraints. Tabular reports gave better decisions but graphs were faster. Their experimental task was more complex than most other experimental settings reported. It involved the allocation of costs to optimize results. It was one of a continuing line of more complex optimization decision environments.

Benbasat and Dexter also specifically identified information overload as a theoretical moderator that may have significant influence on results, especially under time constraint pressure. They noted that information overload could lead to cognitive strain, which causes a deterioration of decision making quality. They hypothesized that the cognitive strain caused by information overload was task dependent and presentation mode dependent as well. Thus tasks such as data retrieval would handle overload better in tabular environments and trend analysis would handle overload better in graphic format. This reasoning added theory to previously noted results (task dependency presentation performance).

7. Bloucher, Moffie and Zmud (1986) introduced decision bias as a dependent variable in an auditor judgment decision setting. They varied task complexity with presentation format and measured resulting decision bias. Based on prior research they suggested that as complexity increases, users will move to simpler decision strategies rather than more complex ones, and that those simpler strategies will probably cue on fewer items. They believed that as complexity increased, therefore, tabular format would be preferred and support better decision strategies.[13]

Their results showed that, as hypothesized, attention to decision relevant variables is enhanced with graphic presentation for simple tasks, but is better with tabular format as complexity increases. They examined their results for covariate effects of individual differences and found no effects. Importantly, they suggested that future research continue to include more interactive effects. They felt time pressure, task incentive and feedback would affect decision performance and should be pursued.

8. MacKay and Villarreal's research (1986) indicated that individual differences in subjects do affect presentation results. This directly conflicted with Bloucher et al. results on individual differences, adding to the conflicting results in this area. Their work suggested that individual differences as well as task orientation govern experimental results.

9. Kaplan (1988) studied the auditor decision making environment and found that auditor expected values estimations were not affected by presentation format within his experimental conditions. This was pleasing to the audit profession as it supported auditor method flexibility and gave at least negative assurance that alternative presentations would not deter from audit examinations. Given at least perceived preference for certain formats such as the use of graphs for trend analysis, this left the profession with the freedom to continue exploring these recently popularized and newly available communication alternatives. Although not specifically examined under experimental rigor, the article indicated that graphic format results in faster information absorption. Timeliness is clearly very significant to auditors. Again, this research wets the appetite but provides only a sense of needed further work rather than answers.

10. Davis (1989) investigated how well four format presentations conveyed financial information to 30 MBA students in an experimental setting. His purpose was to follow-up on prior studies by Dickson et al. (1986), DeSanctis (1984), Bertin (1983) and Bloucher et al. (1986) that showed that format performance was task dependent, and that complexity may best define task environments. Davis used four presentation formats, three graphic and

[13] Note, their dependent variables were decision attributes: 1) the subjects use of correct decision rule and 2) decision bias. Actual decision accuracy was not measured nor relevant to their study.

one tabular. He varied the complexity of information presented and problems. Davis concluded that complexity was a major factor influencing cognitive processing.

Davis believed the best performance would be derived from minimizing cognitive effort required for decision making and analysis. Thus cognitive efficiency varies with task, and that to some extent complexity can define the task as well. Davis believed that problem solution involved the following four step process: (1) general identification, (2) scan [focus within general identification], (3) comparison, and (4) estimation. The presentation that most efficiently affords processing of those four steps will be most effective in problem solution. This line of reasoning closely parallels Vessey's work as mentioned above and presented in more depth later in this paper.

Davis used two dependent variables to define performance: accuracy and elapsed time to reach solutions. Protocol analysis indicated that graphic presentation resulted in holistic processing based on imaging by subjects, whereas tabular presentation resulted in analytic processing. His findings indicated that although complexity did serve in some ways to define task and therefore indicates presentation optimality, task type itself is the overriding factor in optimal presentation format.

11. DeSanctis and Jarvenpaa (1989) looked at forecasting as the decision making task to determine if this type of problem representation favored graphic or tabular (or both together) presentations. They specifically looked to see if bar graphs would improve financial statement forecasting. They felt this work would be important because they believed there existed a "high a priori expectation of benefit from graphical displays." (1898, p. 510). They looked at main effect comparisons of format only. They also introduced another dependent variable of interest, user confidence. Their results showed "modest support for the contention that graphical formats can improve the accuracy of forecast judgments." (1989, p. 509). Confidence findings were not significant.

12. Jarvenpaa (1989) believed that in spite of progress in recent research "the designers of decision support systems lack theoretically based principles for designing graphic interfaces." (1989, p. 285). Her work introduced the theory of "cognitive costs" in problem solution.[14] Jarvenpaa believed that decision sciences should model presentation formats to decision frameworks as defined by the decision at hand. Further, that the best presentation would be the one that has the least cognitive processing cost. Cognitive processing included information acquisition, information evaluation, decision item and the final decision choice.

Jarvenpaa referenced Payne (1982) to define decision strategy as a compromise between the benefits of minimizing errors and the expected cost of cognitive effort. The format that minimizes errors using the least processing cost will be the most successful. Thus format favorability was defined not only as the most successful one but was further defined by ease of use. Intuitively obvious perhaps, but welcome as a formal component of presentation

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[14] In fairness to others, certainly DeSanctis, Benbasat, Dexter, Davis and surely others did precede her in employing theoretic backing in their studies. Nonetheless her emphasis on the importance of theory backed work was significant.

theory and significant to my definition of value that is beyond informational accuracy or content alone. Value includes a usefulness component. Jarvenpaa also introduced the term incongruence. Incongruence occurs when cognitive processing encounters blocks or does not proceed in orderly steps or requires unnecessary additional time. Incongruence adds to cognitive costs. Incongruence affects both decision accuracy and time. Both are important in applied business environments.

Her results supported her cognitive cost theories. She recommended that future graphics research should use both time and accuracy as performance measures. She suggested that knowledge of the cost/benefit framework of problem solution would provide useful guides in predicting which display features would help or hinder performance.

13. Ruf (1990) performed an experiment to see if individual user characteristics had significant influence on cognitive processing and format usefulness. Although there is substantial intuitive ground that individual abilities would influence presentation usefulness, most prior research had either not included user abilities or studies the effects as a covariate only. Ruf's results were mixed. Her revisiting of the user ability issues were, however, welcome. Although her study did not show significant user interfaces, she believed that may have been caused by limitations within her experimental design. She hypothesized the following cognitive model for studying user characteristics:

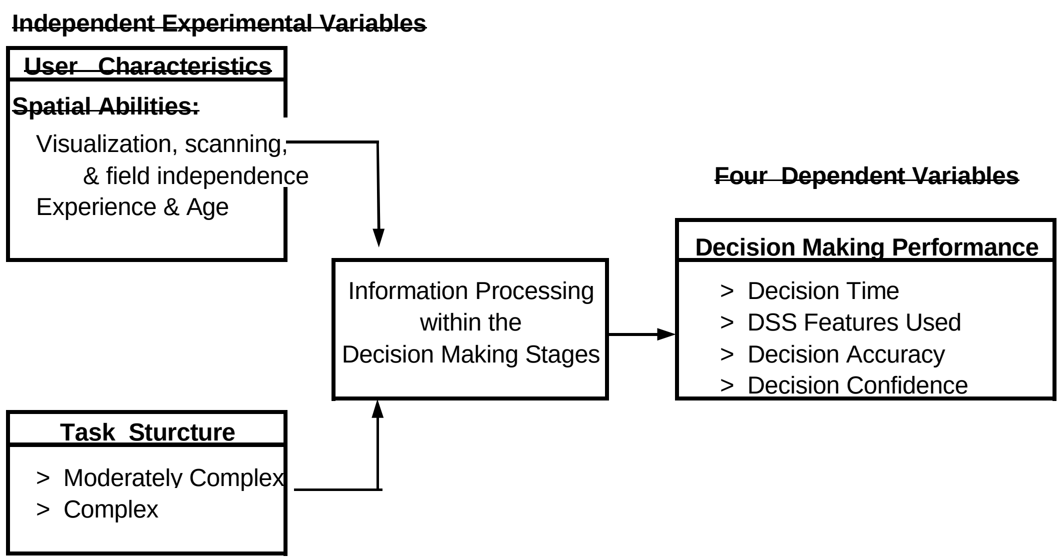

FIGURE 2.2 RUF'S EXPERIMENTAL MODEL

Ruf's theorized interface between task and user characteristics (although not significant in her study) makes sense and warrants further investigation. She believed that the dominant factor may be task oriented, but as the intricacies of presentation format and performance are developed, user characteristics may prove to be increasingly influential as well. Intuitively, given the differences between individuals in ability and cognitive styles this seems to have merit. It also fits nicely into the cognitive fit theories and may explain the reason that so many studies have inconclusive results. It is reasonable that although the experimental factors are significant in terms of influencing decision behavior the differences in individuals in ability and cognitive style preferences adds more variability than random assignment compensates for.

14. In 1992 John Anderson, first with Kaplan and then with Reckers, published two articles in "Advances In Accounting". This research specifically focused on auditor judgments. The first study looked at auditor strategy and audit risk avoidance decisions. The study focused on the interaction between graphic and tabular format, and on the variability in data. The hypothesized interaction had disappointing results, but the main effects of graphic vs. tabular presentation were distinguishable. Auditors were found to set different audit strategies dependent on presentation format. This study involved a more complex decision situation than most previous research. Although Jarvenpaa's cognitive cost theory was not implicitly pursued, it seemed applicable and would have made an interesting a priori investigation of cognitive processing cost that predicted audit strategy based on presentation format alone.

The results implied that the facts or data that drive audit decision strategy may result in different strategies solely based on the manner in which the data is presented. An important audit finding in terms of audit accuracy, in setting appropriate audit strategies and in audit resource utilization effects. These conclusions differed from Kaplan's (1988) findings. Kaplan's audit research indicated that presentation format did not affect auditor decisions. (See # 9 above.) Anderson found otherwise. Anderson's findings are the stronger as Kaplan's "no difference" results could have been because of several unknown factors, including poor experimental design. More significantly, it could have been differences in response variables. Kaplan asked subjects to make analytic calculations and estimates, Anderson looked at the effect of presentation on audit strategy. These are different levels of cognitive processing.

Anderson's second study (also 1992) looked at the ability for auditors to assess correlation's among graphic and tabular data. This study found that graphic presentation fit the correlation decision task best. Importantly, Anderson and Reckers included tests of subjects' field dependence abilities (re: Ruf's [1990] user ability hypotheses). They found that field independent subjects made better decisions (main effect) and that field dependence did have a "modest" interactive effect on performance, as an interaction with presentation format. The importance of this result was that it looked for and found, albeit modest, interactions between task and individual abilities in decision performance.

The fourteen studies commented upon above were valuable steps in presentation research and they did incorporate increasingly more theory. They remained, however, largely results-driven as they lacked a cohesive framework from which to build upon each other. They did not explain the underlying reasons for presentation effectiveness differences and did not build toward useful protocols for presentation modeling outside of the limits of their experimental settings.

Jarvenpaa's inclusion of the cognitive cost/benefit approach was very valuable, as were Benbasat and Dexter's information overload, and Davis' cognitive efficiency theories. But conflicting results still went unexplained from a theoretic vantage, no overall model of cognitive fit and presentation theory developed in a unified way, and the strength of individual ability difference effects remained uncertain.

2.1.2.1 Vessey & Presentation Theory

In 1991 Vessey produced what I consider a pivotal paper that used a theory of cognitive fit to bridge between prior and seemingly conflicting graphic / tabular research to achieve some consistency in explaining results. (This theory of cognitive fit was not new. Jarvenpaa, Benbasat, Dexter and Davis as among those that had worked with related theory.)

Vessey categorized the TASK in prior presentation studies as being either spatial [graphic], symbolic [tabular] or both. She then used cognitive fit to explain how the spatial / symbolic categorization could be used to explain the conflicting results of other research. This use of cognitive fit took the chaos out of the previously conflicting stories. Her results, based on cognitive fit, task-oriented explanations of related research investigations follow:

- Five of six studies that she identified as spatial information acquisition tasks all gave superior results (decision accuracy or time) in graphic format.
- The five studies she identified as symbolic gave superior results in tabular format.
- Three of the four studies she identified as both spatial and symbolic were either inconclusive or gave the best results for combinations of both graphs and tables vs. tables alone.
- There were a minority of exceptions to her theoretic classifications.
- Her theory held for simple information acquisition and simple evaluative tasks, but not for more complex analytic ones. "In effect, these studies represent decision-making tasks that are too complex to be addressed by the paradigm of cognitive fit." (1991, p. 232)
- Complexity became a confound beyond the limits of her spatial/symbolic cognitive fit theory. She defined complexity as tasks that involved a sequence of subtask decision strategies. They were not amenable to simplistic cognitive fit categorization, nor to simplistic presentation fits.

Her work helped with the conflicting results problem and supplied cohesive theory to bridge between studies. She replaced the impasse from somewhat conflicting research with a simple theory grounded in existing psychological doctrines. Again, in fairness to other researchers, she was certainly not the first to do so. Even my brief summary of research above indicates that others had similar perceptions. But her work did pull together previous work with a unifying theory and gave a more clearly defined research explanation to pursue.

As her analysis was based on post hoc explanations of completed studies, she provided not only a plausible research path to follow but plenty of opportunity for new validation research. Her explanations covered basically simple mental representations. Her theory was wider, so this too inspired further theoretic work in the development of explanations for complex decision task phenomenon.

Vessey theory described task-oriented cognitive fit as being one where problem representation matches with problem solving processing (task). She calls the matching of representation with task "cognitive fit." Cognitive fit affects task performance and explains results of applicably defined graph vs. table research. She uses the following general model to illustrate the theory.[15]

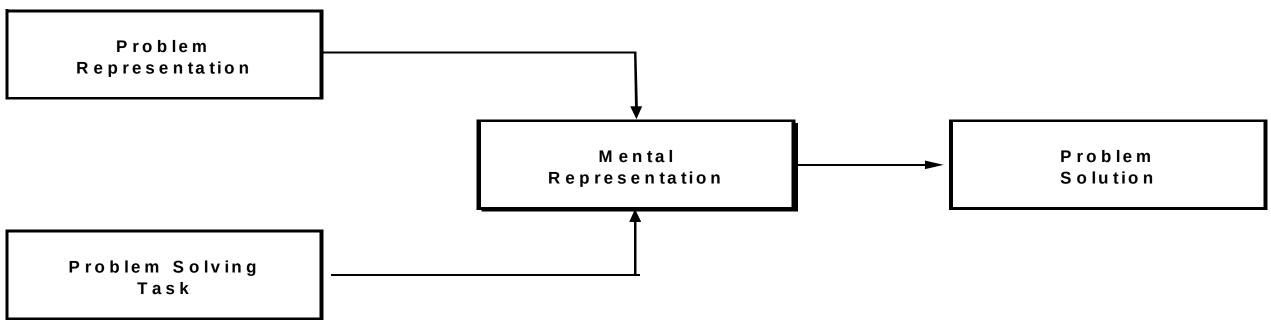

FIGURE 2.3 VESSEY'S COGNITIVE FIT MODEL

Vessey believed that for future research to be valuable the nature of the problem solving task must be included at least as a mediating variable. For Vessey's simple tasks of information acquisition, leading to the most efficient mental representations and therefore problem solution, she uses spatial (graphic) or symbolic (table) categorizations as follows:

- Spatial representations are best for: Comparing patterns between data, perceiving relationships, identifying trends, and interpolating values. This can be classified as a PERCEPTUAL PROCESS.

- Symbolic representations are best for: Retrieving discrete data points and data point recall. This can be classified as an ANALYTICAL PROCESS.

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15   Note she herself uses a spatial presentation to communicate her theory. Readers internally process the interrelationships spatially; communication of the relationships is therefore more effective in spatial mode, rather than verbally, which the reader would then have to translate spatially to process.

> [Some more complex analytical processing is facilitated by tabular presentation as well, but this is situationally dependent and not as readily categorized.]

Mental representation symbolizes the way working memory will process data to arrive at solutions. Accordingly to her model the characteristics of both the problem and the task reach optimal solutions when these characteristics are harmonized initially. Thus efficiency is achieved when the format of problem representation matches with the process required to solve the task. If the representation and the task are not coordinated, translation of the problem representation is first required before processing can occur. Optimal mental representation results when data presentation and task merge without further mental processing.

> "Matching representation to task leads to the use of similar, and therefore consistent, problem solving processes, and hence to the formulation of a consistent mental representation. There will be no need to transform the mental representation to accommodate the use of different processes to extract information from the problem representation and to solve the problem. Hence, problem solving with cognitive fit leads to effective and efficient problem solving performance." (Vessey, 1991, p. 220).

Failure to match the presentation data with the task requires that either the task be transformed to fit the data or the data be transformed to fit the task. An effective mental representation, needed for solution, is delayed until one or the other transformations occurs. Such a mismatch adds further complexity to the solution process, requires more time and exposes the process to unnecessary transformation error. Performance suffers, regardless, when data representation does not match with the required task.[16]

Vessey [1991] uses the foregoing to arrive at two [somewhat self-evident] propositions:

> Proposition 1: Problem solving with cognitive fit results in increased speed and accuracy of performance.
>
> Proposition 2: Problem solving without cognitive fit does not result in performance effects [increased speed and accuracy of performance].

Although the logistic need for proposition 2 eludes me (corollary to #1?), the simplicity of the statements serve well the study of graphic and tabular presentation efficacy. Vessey borrows from the psychology literature to categorize data in one of two ways: images or words. Data exists in working memory as either images or words (verbal) according to this line of thought. Graphs convey images (spatial) information and tables convey verbal (symbolic) information.

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[16] Vessey [1991] cites three bodies of literature that support her cognitive fit, mental representation theory. These are: human information processing, judgment under uncertainty, and behavioral decision making / consumer behavior disciplines.

Further, she speculates that spatial representation facilitates "viewing" the overall message/image of graphic information. Graphic presentation provides the best link to human perceptual or basic sensory type processing. Conversely, if identification of discrete data points is necessary for problem solution for simple analytical tasks, then symbolic presentation facilitates solution. So another depiction of the differences is that of perceptual or sensory vs. analytic processing.

The categorization of tasks into perceptual, image friendly tasks or discrete data analytic tasks will help determine the optimal visualization format. This is exactly what Vessey did in her 1991 study that transformed seemingly conflicting research results into presentation conventions. Her conclusion: presentation that facilitates harmonized mental representation is: (a) task dependent and (b) results in solution efficacy.

Critical to this approach is the understanding that this is only a first step in the presentation / problem solution process. Vessey's presentation framework works only for simplistic decision making activities. But it works very well indeed for such elementary tasks, and as noted, has provided welcome answers to previous research that lacked cohesiveness. In the studies that Vessey cited as remaining inconclusive she characterized the task as a mix of both spatial and symbolic problem tasks. This included several business simulation studies requiring various optimization decision processes and simultaneous information assimilation. They were complex situations.

In 1994 and 1995 Vessey published follow-up experimental research (1995 was with Umanath). She also collaborated on a working paper with Christ in 1994. These investigations pursued the cognitive cost theory and further developed a mental representation concept as a model to frame the decision making process relevant to presentation issues.

Vessey's theory in these works began with the simple premise that inputs to decision processing resulting in the least processing effort will be most effective. (Effectiveness is defined by both precision in solution and time required.) This is basically the cognitive cost theory that Jarvenpaa (1989) discussed.

Reduce complexity in the task environment and more effective problem solving results. The task environment is communicated via presentation input format. Simplification of input (complexity reduction) is achieved when the internal problem solving process is most compatible with input format. Put simply, it requires less cognitive work for people to process information that is presented in a style ready for processing rather than as information that must first be internally transformed before the problem solving processing can commence.

For example, although Roman Numerals may satisfactorily represent numeric information, they are cumbersome for even simple mathematical calculations and must be translated to Arabic or other representations before non-trivial calculations or fractions can be attempted. The Roman format requires an extra step in problem solution making calculations more complex, more prone to error, and more time consuming. A computer analogy perhaps also serves the point well. Computer languages that are easily learned by humans require very complex translation programs (compilers) before the computers can actually perform any processing. Very adept human programmers learn what is called ‘machine languages’ that are closer to the data format with which computers will perform their processing. This results in faster computer processing -- it facilitates computer performance just as micro-circuitry does. Machine languages achieve “cognitive fit” for the computer.

Similarly, tasks that will be processed spatially internally are theorized to be most efficiently handled if presented in spatial format to begin with. This includes tasks such as simple relationships between numbers and trend lines. Conversely, data extraction is most often a symbolic internal process and most effective if presented as simple numerics rather than in graphic spatial format. Graphic format would require translation into numerics before processing.

Moving Vessey’s theory along with industry advancements in presentation, Dull (1997) proposed to extend the basic graph and table interests to three dimensional representations. “It is reasonable to conclude that if one’s experiences are from a three dimensional world, representations on which he or she might make decisions may be understood better in that format.” (Dull, 1997) Vessey’s cognitive fit explanation coincides well with Dull’s observation. Task orientation is probably manifested beyond simply spatial or symbolic representations, but is sensitive to representation varieties as well.

Tufte has written several books on visual display and information transfer (1983 & 1990) as have others. Cooper (1990) theorized that individuals might in fact unconsciously translate two dimensional representations into more realistic three dimensional mental images. If so, this translation involves yet another stage in cognitive processing, and necessarily complicates the process. Thus presentation may add a level of complexity, independent of, but adding to, the overall complexity level of the problem itself. One sympathizes with this logic, yet for simple problems such as determining a linear trend the less complicated two dimensional presentation seems preferable to a realistic, three dimensional model of the phenomenon. Again, simplistic answers will not serve human cognition.

2.1.2.2 Summary of Presentation Theory

Mental representation is important to effective cognitive processing. This leads to optimal problem solution and decision making. Mental representation efficiency is a function of the (1) task encountered (Vessey), (2) familiarity with the representation presented (Dull), and (3) translation difficulty required prior to mental processing (Cooper).

Presentation format, mental representation and cognitive processing are all closely related to the first factor of my research (information content / complexity) as both presentation and complexity respond to decision framing and, I theorize, to each other. Congruence in task and problem presentation aids effective processing. Additional decision-relevant information contributes to effective decision making up to a point of information overload.

That point of overload will vary with the efficacy of mental representation. And mental representation is affected by presentation format. To put this together: (1) task complexity and presentation react with one another, (2) congruence in mental representation for the two will optimize cognitive processing.

Presentation and its interaction with content & complexity, which is the ABC factor in this research, is perhaps the most interesting of all factors and interactions. Communication capabilities are exponentially expanding, as are computer usage and the visual capabilities of the computers being used. As argued a few decades ahead of time, “the medium is the message.” The function of accounting is communication and communication is a function of presentation. Better understanding the behavior of that presentation function is one of the goals of this research.

2.1.3 Decision Bias & Decision Framing

Another observation related to cognitive fit theory is that once decision makers have reached an analytical framework from which to solve problems, they will tend to stay with that framework regardless of additional demands for accuracy or timeliness (Vessey 1994). Similar to mental representation, which is the internal representation of information, external framing can have a significant effect on decision making. Kahneman and Tversky (1974 & 1981) showed that people will selectively use information based on framing. Biased decisions result from this selectivity; people tend to select information that conforms to their initial problem frames or mental representations.

Decisions made based on quantities of information rather than quality can lead to a form of confirmation bias that will distort effective decision making. Greenwald (1986) refers to a classic study where people are three times more likely to properly identify blurred images given one slightly blurred picture than when people are allowed to view the picture continuously from a very blurred stated to the slightly blurred state. Curiously, those given the additional information were much less likely to make correct identifications. The reason is that the additional information was used prematurely; the premature decision, based on poor data, interfered with subsequent effective interpretation of more precise information. That such bias will have stronger effect in the presence of more accurate information is exactly the interactive effects sought in this research.

Greenwald et. al. (1986) begin a treatise on scientific research in general in which they propose that researchers are naturally prone to obtain theory predicted results by a process of directed perseverance (confirmation bias). They believe that not only does this bias results, but it stifles creative opportunities as well.

Research in decision bias dates back at least to Merton’s 1948 “self-fulfilling prophecy” concept. Greenwald et. al. (1986) cite some twenty-two research articles on bias phenomenon. The literature generally supports the premise that people will select and frame information in a way that is consistent with prior experience or be biased by initial problem framing. Bias or decision framing bias will affect cognitive processing. This effect should have standalone or main effects in the decision process, but, more importantly, should affect other decision influences as well. Specific to this study, bias should affect both decision accuracy and decision time as an independent factor and should register some effects interacting with information content (ABC/VBC) and presentation.

Recent business research has also popularized decision bias and decision framing. There are many business situations where decision bias is applicable, but none perhaps as conveniently well suited as auditing. Simplistically speaking, the primary output from an audit is the audit opinion, which, again simplistically, is either "clean" or qualified. Tremendous resources go into this dichotomous output and tremendous consequences can depend on the opinion. Meanwhile the inputs to the audit decision are anything but dichotomous. Many of the inputs to the opinion are subjective and therefore, arguably [strongly] subject to decision bias.

Surprising to the psychologists, but perhaps somewhat "conveniently" pleasing to the audit profession,[17] decision bias is less conclusively present in audit studies than demonstrated in more generalized decision bias research. Ashton and Ashton (1990), Butt and Campbell (1989) and Asare (1992) attribute the inconsistent research results on auditor training. Church (1990) believed poor research designs contributed to the conflicting findings.

Ashton and Ashton (1990) compared the evidence of bias between auditors and business executives. They found bias in decisions of business executives but not auditors. Evidently the literature supports the existence of non-audit bias in business as consistently as in the general research.

Consider that bias can often be a positive influence. What is bias other than the formation of conclusions based on prior experience? Often this is the essence of the learning process. If the prior experience is relevant to present decision circumstances then this process in fact defines the elements of productive decision making. Bias can give us initial framing in decision making. While such framing surely may stifle creativity, creativity does not always lead to the best or certainly not the most efficient decision making. This "positive" bias effect is perhaps strongest in the somewhat routine, profit oriented business decision situations. Framing bias here may stifle creative approaches, but also may provide useful direction and assist in forming productive strategies.

There is evidence that decision bias and framing is stronger if: (1) people commit explicitly and verbally to a position, and (2) they choose that position rather than have it designated to them (Wicklund and Brehm, 1976; and Church, 1991). These accentuating conditions are utilized in any experimental design. Whether the accentuation phenomenon is a result of the need for conscious self-justification or the more subtle effects of mental representation and problem framing is interesting. Interest aside, however, this study limits itself to examination of the results of framing bias. It leaves the differentiation between the

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[17] Perhaps a little of Greenwald's' own researcher's internalized confirmation bias is at work here.

justification and more cognitive related mental representation subtleties to future investigations.

The detection of framing bias in decision making is significant to learning about problem solving accuracy and the decision process itself. While bias is an important factor in itself it is perhaps most interesting because of its effects on other decision influences. This research is designed to precipitate measurable changes in decision making in association with changes in information content and presentation. The two-way, and perhaps three-way interactions should provide value insight into the factor influences on decision making.

Recall this study examines decision making under repeated trials. Each trial has the same business problem and the same experimental conditions of influence. Creativity and sporadic approaches to decision making will be less productive than the development of a consistent rational approach. Focus rather exploration will benefit performance. Framing will hurt if it leads the participant to stay with unproductive strategies. Framing will help if it leads to improved strategies, and most importantly, influences the participant to fine tune good strategies.

Turning to the interactions of framing bias, it is anticipated that the more chaotic the problem setting the more help the framing bias should be. Information content is most clear in the ABC environment. While framing should be a positive influence for both ABC and VBC environments, framing should be the most beneficial in providing focus and direction in the less predictable and more frustrating VBC decision environment. As no direction is predicted for the presentation main effect the influence of bias interacting with presentation is not directionally predicted. An effect is anticipated for the interaction, but whether framing will be favorable to graphs versus tables is unknown.

Vessey (1991, 1994) reminds us that cognitive fit is most productive when the fit is reached. ABC provides better decision information to the decision maker. I extend Vessey's theory to ABC by hypothesizing that framing bias will have less effect on the "cleaner" cognitive fit of ABC better than the more frustrating VBC that is cluttered with less clear decision information. Put another way, the noise from the less accurate VBC information will interrupt the cognitive fit and provide more resistance to effective decision making when the bias effect is not present. Bias should be a stronger influence in the VBC environment. Focus, selectivity and framing plays better to pandemonium than order.

Is framing bias always a positive performance influence? Of course not. Often, reluctance to adapt to dynamic circumstances impedes effective decision making. Business graveyards are full of examples. How did IBM go from its pinnacle of success to near catastrophe? Reluctance to change -- reluctance to even recognize the need for change. Successful business decisions need to be receptive to change. The models used in the experiment represent a static decision environment, however. Optimization of variables that are anchored in their surroundings is sought. The conditions are dynamic from experiment to experiment, but within each experiment they are governed by the exact same decision optimality conditions. Therefore the participants that can reach consistent and positive strategies quickest will perform best. The result should be that the positive decision bias gives incentive for participants to stick with good strategies. On a practical level, these static decisions are analogous to the more routine or practical and tactical decisions of a short-term nature that a business faces rather than the long-term, strategic decisions. The problems that an engineer or salesperson or plant manager faces rather than the issues facing the board of directors.

Decision strategies in these stationary decision environments that develop consistent approaches will be most helpful to users that have environments that need the most help in organizing solution approaches. The more chaotic VBC information is such a situation. VBC decision feedback is somewhat "off-target" and not always easily interpretable into problem solution clues. In these decision situations framing incentive should be effective for both ABC and VBC, but provide more positive help to the VBC conditions.

Bias, and its effects on problem framing and decision making, is related to both the cognitive relevancy and presentation format issues raised above. The diminishing returns of additional relevant information, the cost of complexity, is similar, in effect if not in cognitive mechanism, to the potential effects of confirmation bias on decision making. Similarly presentation format may, by virtue of (1) realism, (2) familiarity or (3) conformance to task representation, enhance or disrupt efficient problem solving.

Recall Vessey's stage of problem solving representations, Cooper's translation of mental images, and Greenwald's selectivity biases; all affect the efficiency of problem solving. Complexity, presentation and confirmatory behavior all interact with problem solving stages, and all interact with one another. The result of these interacting combinations is efficient problem solving for the correct combination of conditions and inefficient problem solving otherwise.

For example, one might say that for complexity, presentation, and bias there are some levels where "less is more." The influences of the individual factors change dependent not only on the particular factors themselves, but dependent on the dynamic influences of the other two factors. That is, the level of diminishing marginal returns for complexity will vary dependent on the strength of bias and again dependent of the mental image that is effected by various presentation formats. The level of bias or presentation format may affect the point of diminishing returns for the content factor as well. Hence the importance of the interactions among these factors, and the reason that these three factors were selected: they are hypothesized to have such interactions.

2.2 Research Question & Hypotheses

The overall purpose of this research is to learn more about managerial decision making and the communication of decision relevant information. Of primary interest are the influences, positive or negative, that information content, presentation, and framing bias have on the communication of analytic accounting information.

While much research has centered on the main effect variables of (1) content/complexity, (2) presentation and (3) cognitive biases, this research has a unique perspective in its ABC grounding. ABC effects and interactions are of primary interest. Berg and Sprinkle (1995) have demonstrated that ABC information supports better decision making under certain experimental conditions. My study extends this premise and goes further by questioning ABC's effectiveness under different presentation modes and under the influence of decision biases. These interactions take previous research one step further in probing the complexities of decision making and one step closer to the conditions actually found in real business situations. Especially pertinent to today's "Internet environment" might be the differences noted between the presentation interactions. Are all the advanced graphics truly helpful, or are they distractions?

Of course, while the interactions do bring us closer to the real world, the experimental conditions are still far from the realism of everyday business situations. None the less, it is hoped that insight into cognitive processes will be gained from results of the research.

<u>The explicit research question is:</u>

Does: (1) information content, (2) presentation format, (3) framing bias, and (4) their interactions influence the interpretative value of cost information in making business decisions?

This study purposefully focuses on the two rather than three-way ABC interactions. While the more complex three-way interaction simulates dynamic business conditions more realistically, I believe that before moving to the difficult analytical level of three way interactions, the two-way relationships should be thoroughly examined and understood. The three-way interaction will be included as an additional research question, but until more is learned of the hypothesized two-way relationships, theory development is not sufficient to support a three-way interactive hypothesis.

In context with the cognitive cost [of added complexity] theory introduced previously, it is possible that the more complex three-way interactions may have stronger effects than simpler two-way interactions. Correspondingly the two-way interactions may be more influential than simple main effect reactions.

The main effects are of course important to this investigation. They carry forward prior research in a different decision context. It is presumed that the informational content main effects (ABC factor) are significant. Indeed this is a necessary condition for the study. Without ABC [positive] main effects the entire study has less interest. The research is designed around the presumption that the improved ABC information is decision-relevant. And that that relevance will manifest itself in terms of improved decisions and improved profits in the simulation.

Although the interactions could very well be significant (and interesting) without significant main effects, the main effect for ABC is considered a manipulation check for the study as well as an important main effect.

Presentation and bias main effects are similarly desired but not critical to the research. As the many preceding presentation studies show theory is far from settled. I can not predict direction for results between graph and table presentations. Bias is similarly complex and unsettled in terms of theory. Bias can be positive or negative in its decision influences. Under the framing conditions I am using bias should be valuable to problem solution.

2.3 MAIN EFFECT HYPOTHESES

H#1: **ABC information will have a positive effect on decision making compared to traditional Volume Based Costing (VBC).**

H#2: **The use of either graphical or tabular information will have an effect on decision making.**

H#3: **The presence of framing bias will have a positive effect on decision making.**

These effects and support for these hypotheses were discussed in detail in their respective sections above. For both main effect and interacting hypotheses the hypothesized response variables are profits and time. For profits, more is better; for time, less is better. Response variables are discussed more fully in Chapter 3.

2.4 INTERACTION HYPOTHESES

H4: **Presentation format will affect information processing differently dependent on the feedback accuracy (content: ABC vs. VBC) of the information presented.**

Presentation factors are operationalized at two levels: (1) tabular, numerical listings of cost functions and profit results, (2) two-dimensional bar graphs of the same data.

Cognitive problem solving is task oriented. To varying degrees problems may be facilitated by presentation in either spatial or symbolic format. The superior value of the ABC information is relevant to the problem solution but the ABC information is more detailed than the VBC information. This additional information may be processed more effectively visually through graphic representation or may be more friendly to numeric presentation. In addition, the ABC information is more accurate. It allows for simpler and more straightforward strategic analysis. VBC information contains noise that confounds precise internal analysis. The clouding by the VBC information interrupts efficient mental representation. Cognitive fit is not facilitated.

These manifestations of the content and complexity issue make prediction of the direction of the presentation effect difficult. Their presence, however, should result in more effective processing given one form of processing over the other. The interaction of content and presentation should show different responses as each is varied with the other. “Cognitive cost” should manifest differently between these two factors.

ABC information may have the best or most direct decision representation in the simplest of presentation modes, but be less valuable (useable) as presentation mode changes. The effect on VBC information may be directionally similar but of a much greater magnitude as presentation mode changes. Thus the interaction of content and presentation is significant.

These positions are consistent with Vessey’s (1991, 1994) mental representation, framing, and cognitive fit theories, Benbasat and Dexter’s (1985) information overload theory, Davis’ (1989) cognitive efficiency theory and Jarvenpaa’s (1985, 1989) cognitive cost theories.

H5: Framing bias will have a more profound positive effect on VBC decision making than on ABC decision making.

The decision problems presented are static within each measured set of experimental conditions. Effective solution require comprehension of clues provided by the ABC or VBC information provided by feedback to repeated trials. Framing bias will be more helpful in deciphering the less accurate VBC information that it will for the more straightforward ABC information. Subjects will be more prone to inconsistent behavior given the confusing VBC data. Training wheels help those in need of assistance most; framing is of the most benefit in the cluttered environment. The static, repetitive nature of the decision environment encourages the discipline that framing adds to the analytic process. Creativity, stifled by framing, is of less analytic value in this decision environment.

Effective decision making requires making the best of available information. Available information for ABC will provide valuable insights for problem solution. The additional incentive that framing bias adds to consistently analyze the less direct VBC feedback will prove more valuable for VBC than for ABC.

Framing bias is most helpful in the less analytically penetrable VBC information setting. While framing should be beneficial to both ABC and VBC, it should be significantly more helpful to VBC. The should be a measurable magnitude of difference between the framing effect for ABC and VBC. The “cleaner” cognitive fit provided by ABC information will be less affected by the positive influence of decision framing.

H6: Presentation format will affect subject performance differently dependent on the presence of framing bias.

Framing bias will affect performance as the decision visualizations vary. Possible covariate analysis may show that spatially oriented subjects can utilize framing biases more readily given complex graphic visualizations than subjects for whom complex visualizations are more challenging to process. As the presentation main effects are not directionally hypothesized, direction of the presentation and framing interaction cannot be anticipated either. Presumably framing will have a greater magnitude in effect for the mental representations afforded by visual graphics versus numeric listings. The benefit to this static analytic problem of repeated trials should be greater for one visualization than another.

This issue is interesting but the research appeal is somewhat tangential to the overall study, which is primarily directed toward understanding the more directly related information content (ABC) issues and interactions. Regardless of informational content, mental representation differences from graphic or tabular presentation are processed differently. The framing influences on these graphic/tabular representations should affect cognitive fit and resulting decisions differently. Knowledge of the anticipated interaction will contribute to the overall understanding of presentation and framing in decision making.

Research Question on the Three Way Interaction:

Do the information content (ABC/VBC) and the bias interactions have differing effects from one presentation formats to the other such that all three factors have non-parallel interacting relationships? This is difficult to conceptualize. It attempts to track multiple factor interdependencies. This means tracking the behavior of eight combinations of interactions of these three conditions, and understanding or predicting effects under each of the possible condition changes.

If the relationships between all three factors are not predictable based on observance of known main effects or second order interactions it may still hold that the three variables themselves may have a unique alliance with one another. Significance of the three-way interaction are considered exploratory.

CHAPTER 3

Experimental Design & Methodology

3.1 Overview of the Experiment

The hypotheses were tested using a 2X2X2 mixed factor experimental design (Exhibits 1 & 2). The experiment was conducted using strict experimental controls with the objective of achieving high levels of internal validity, which I believe was accomplished. All participants were randomly assigned to experimental conditions. This design was structured for ANOVA; MANOVA and ANCOVA results were also explored.

Participants performed the experiment four times each, representing the four possible combinations of crossed experimental conditions. Ordering for these four conditions was completely counterbalanced, eliminating confounding from sequencing (Exhibit 4).

A computerized business simulation was written to incorporate the three experimental conditions of interest. The simulation was a simplified model of a profit-oriented business in which the participants' objective was to achieve the ultimate goal of all businesses: profit maximization. Participants [players] made product volume decisions in the game to seek profit maximization. All other business decisions and conditions were internal to the game. Players were given sales, cost, and profitability feedback after each of twelve trials included in each game. This feedback formed the basis for their next profit maximizing decisions.

The game was completely automated and player-interactive. Other than brief introductory greetings by the experimenter, players were one-on-one with the game [computer]. The computers were located in small individual cubicles in a computer lab at Virginia Tech. The computer dispersed all game instructions, collected demographic data, started each game at the players prompting, ran the games, recorded the detailed results of each trial of each game, and exited the program at the end of the games.

Players seemed to be very comfortable with the computerized environment. They had all completed Virginia Tech's two required computer courses, and none had trouble moving around the computer simulation. To several the experiment seemed to be an extension of video games. These games took around twenty minutes each to play. Completion of the four games plus an abbreviated preliminary practice game took the players about two hours to complete. No one complained about the time. The combination of the high potential player rewards ($100), the competitiveness of the situation, and the attractive computerization of the game made the game fun and exciting for most players.

At the completion of the experimental session (4 games) players were given two, two minute spatial ability tests by the experimenter and thanked for their cooperation.

3.2 Participants

Forty-eight full time undergraduate business students from Virginia Tech were used as participants. They were solicited from Cost One classes (Exhibit 3), which is a required course for accounting majors; all participants but one were accounting majors. Students in all five of the Virginia Tech Cost One classes were solicited by the teachers of the courses. They were asked to sign up as a volunteer if they were interested.

Sixty-six students volunteered to participate (Exhibit 13C). Of that number forty-eight students actually did participate. Participation was finalized based on student choices for available times on a sign-up sheet. Times were scheduled from 8:00AM to 5:10PM in fifty minute intervals for five days (Monday through Friday, November 3rd to 7th, 1997: Exhibit 3).

The experiment was a challenging intellectual exercise for the participants. Participants were told they would receive two points of extra credit if they finished in the top half within their assigned groups of eight players. This was my intention. In fact, the three teachers involved later decided to give students credit if they participated or had volunteered regardless of their performance. This was, of course, their prerogative. At the time of the experiment, however, students were told that extra credit, like the monetary incentives was strictly performance based.

Participants [players] were paid a minimum of $5. Importantly, they were given the opportunity to earn very significant bonuses. Within each sub-group of eight players that the participants were randomly assigned to, the top performing player [highest accumulated game profits] earned $100. Second place within the group of eight received $50; third place got $20; fourth place got $10 and the remaining four players received the minimum $5 payment. This meant that 25% of all players earned at least $50. In addition, in two of the four games each player played they were given the opportunity to earn an extra $25 based on the strategies they pursued.

Participants were randomly assigned to groups and experimental conditions using a the random number generator in Microsoft's Excel software. Spatial ability tests were given to the participants after they completed all four computer games. The computer itself collected demographic information that was considered of interest and as a possible covariate.

As noted by several presentation researchers, students are entirely appropriate for this experiment:

1. The results of this experiment concern innate problem solving mechanisms and problem solving theory. This cognitive process is common to all human thought processes. The experiment's intent was to learn about that cognitive process. The actual simulation of the very complex real-world profit maximizing business conditions is not possible under such controlled experimental conditions.

Similarly it is the cognitive process that is of interest, not the business people. Generalizability of a specific aspect of this study to particular business situations is an unnecessary stretch. The nature of the laboratory settings and tasks included in the study are hardly intended to replicate business conditions. (The tasks are purposefully simplistic, have highly uncharacteristic time constraints, and use limited data.)

The theory examined in this research is expected to be generalizable, not the specific experimental conditions. This reasoning applies to the subjects as well. (Mook's work gives eloquent support for this position, 1983.)

2. With specific reference to the variables included in this study, one might argue that ability to utilize ABC information is business-experience related, and that it is not an inherent cognitive function. The construct of interest, however, is the information content associated with the ABC information. It is the relative ability to assimilate, interpret and utilize ABC information, together with other factors that is of interest. Certainly spatial and symbolic ability, decision framing, and presentation preferences are characteristics inherent to all humans and of interest in theory development.

   With that said, the design is complimented with participants that have developed a basic level of analytic skills and are familiar with at least the basics of business and financial reporting. These participants, all accounting majors, had completed at least two semesters of accounting prerequisites as well as other business, statistics, economics and math courses.

3. Given that theory explanation is more crucial to this study than generalization to business conditions, the opportunity to use a group of subjects similar in ability and demographic characteristics limits confounding, variability, and allows for more opportune focus on the theoretical issues.

3.3 Experimental Task

3.3.1 Generalized Approach

The field of experimental economic research has very successfully employed interactive economic models. Among the advantages of this approach are replicability, simplicity, and control. By using a controlled environment, created and fully understood by the experimenter, a minimal or "best shot" test of theory can be made. If theory cannot be demonstrated under these simplified and "contrived" conditions, there is probably little reason to pursue that particular theory. (Davis and Holt, 1993).

There are abundant examples of experimental market models that have successfully simulated market conditions that can be used as starting points for the proposed experiment. My research drew on these models, but directed itself toward a single-player optimization game rather than the supply and demand market mechanisms common to most experimental economic studies. The model was be simplistic, easy to learn, and self-contained in that all experimental instructions, including practice sessions, are internal to the computerized model (Exhibit 5). My experiment was a blend of the experimental economic modeling and the presentation research covered in Chapter Two of this paper.

The final optimization model contained four sessions, each including twelve repetitive trials. The trials are represented as years to the players. Regardless, they were repetitions under the exact same experimental conditions and using the exact same profitability functions. Players were expected to use feedback from each year to improve results of the next decision point [the next year].

There were certainly some learning effects from game to game. This was undesired. The game to game learning, however, did not distort in any way the validity of the statistical conclusions. This is because the four independent games were completely counterbalanced. This sequencing obviates effects from ordering. Additionally, the tasks are simple enough that the learning curve should essentially level off during the preliminary practice sessions. Remaining learning effects, although present were not strong. And the profitability functions changed from game to game. Knowledge about the specific behavior of the profitability function was of no value at all from session to session. An optimal solution in one session often resulted in very severe losses in another session.

3.3.2 Specific Experimental Task And Experimental Procedures

The six hypotheses and one research question was tested using a controlled, laboratory experiment that utilized a three factor mixed-subject factorial design [2X2X2]. The influence from the three factors of interest was measured separately on two response variables. Performance, response variable number one, was measured by the amount of profits earned during the experiment. Time take to arrive at decisions [regardless of decision results] was measured as response number two. Univariate and multivartiate analyses were performed on the response variables.

The hypotheses included three experimental factors of interest, each with two levels. One factor was nested. This split the participant pool into two groups of players that performed the experiment four times. The four repeated experiments included all combinations for the two crossed factors (2X2). These four experimental combinations were completely counterbalanced. The counterbalancing included 24 different combinations (4!).

Players were greeted at their appointed time by my assistant. She had them read and sign a consent form (as reviewed and approved by the Virginia Tech IRB. -- Exhibits 6 & 7). They were asked to wait until I could set them up in one of the private computer cubicles in the Virginia Tech behavioral lab on the third floor of Pamplin Hall. The wait was generally a matter of minutes, if at all. I told all players that the game was completely computerized, including the instructions. I set up their games. This included starting the game program. I initialized each game with the player's assigned experimental conditions. (These conditions were randomly assigned to players.)

Once ready to begin, I repeated to the players that the game was completely automated. I told them that they shouldn't need any help, but that I would be available if they had any questions. I told them that the game would lead them through a practice session and that they should call me at the end of the session to reset the computer to begin game one. A few subjects did call me, perhaps three or four in all -- and those were during the practice game. I was very brief in responding in those cases. I simply told the players to reread the instructions and that was sufficient.

The instructions are included in Exhibit 5 to this paper. They told players how the game worked mechanically and how results were scored. They were told that their incentive pay was based on accumulated profits from all four games, but that the very worst year (12 years to a game) would not be counted in each game. The computer suggested that they use this opportunity to "play around" with extremes.

After year three in each game, players were given additional instructions that reminded them to focus on their feedback and that the key to winning the game was in understanding overhead (Exhibit 8). This was done to reinforce the importance of overhead cost analyses to them. They were given various smaller, one-sentence reminders of rules and incentives during various other periods as well.

The game would not start until they were satisfied with the instructions and comfortable with everything. They signaled to the computer to start the game by typing "ready" when they were ready to go. The players input their four product volume choices one year at a time. After the last product volume was input by the player (in any order) the computer automatically closed out the year and printed sales, cost and profitability results for the players examination (Exhibit 9). A printer was direct wired to each player computer. The printer was next to the computer.

The players would analyze the profitability feedback on the printout and then make product volume decisions for the next year. This process repeated for each of the twelve years in each game. The computer recorded all responses and results (including elapsed times) for all years in each game. At the end of the game the computer automatically saved everything in separate files and exited the software. Players then called me to set up their next game. Times were only recorded during individual games. Time between games was not relevant.

When the players finished all four games I escorted them to another room and thanked them for playing. In the other room my assistant gave them two spatial ability tests (Exhibit 11). The test used was the "Cube Comparisons Test." This is a standard test put out by the Educational Testing Service. It examined an individual's capacity for abstract visualization. It is considered a very good indicator of spatial ability and has been repeatedly used in psychology experiments. Each test was timed. Participants had only two minutes to complete each test.

After the testing my assistant thanked them very much for participating and told them that they would be told how well they did and paid within a month. They were all given a “exit” memo (Exhibit 10) with these comments and my phone number and email.

Students were mailed results summaries, comparative rankings and checks for the money the earned on December 5, 1996 (Exhibit 13). Student’s professors were given summaries of participation and summary results for extra credit purposes (Exhibit 12). The experiment cost $1,200.

3.3.3 Decision Task, Game Mechanics & Computerization

Players were told they were in the business of making baseball equipment. They had four baseball products that they could decide to produce at any level from zero to billions of units. They set production levels choose from bats, balls, gloves and pitching machines (Exhibit 5 for instructions and Exhibit 9 for sample game results).

Prices were fixed and constant for each product. Demand was infinite (all production had a ready market). Costs were governed by the three normal factors of production, material cost, direct labor and overhead. The material and direct labor cost functions were based on constant unit variable costs. Players were not told this, but were given ample feedback to readily determine it. Overhead was governed by six cost functions (Exhibit 14). These functions varied from simple linear functions to extremely complex exponential functions. Furthermore the overhead cost functions were inter-related. Just as in real business, the production of one product would affect overhead costs of another. Thus a change in production of baseballs, for example, would affect the overhead cost of producing bats, even though the production of bats was held constant. The overhead cost function was basically “unknowable” by all but a “Young Einstein.”

Profit maximization was achieved when marginal costs equaled the prices of the products (marginal revenue @ constant price). Although the calculation of this point was not possible by the players, players were given adequate feedback to be able to intuitively move toward optimal levels. Some players did better than others. That is the nature of people, and was the objective of the experimental design.

The cost structure of the game mimicked real business very nicely. It was possible to make a small amount of money (maximum earned in any year was $100,000) and it was very, very easy to lose a lot of money (maximum loss was $172,000,000).

The game utilized Microsoft Excel as a computing software base. The screens were spreadsheet based. Automation was accomplished by very extensive use of Excel’s Visual Basic programming capability. The finished game looked nothing like an Excel spreadsheet. All toolbars, scrolling bars, menus and other screen visuals were removed. The screens were all colored and gridlines were eliminated. Screen location and movement from place to place was completely controlled by the computer. Player responses triggered automated computer responses. Everything was file protected. Excel file sizes were about 1.7MB. These were large, very complicated files. There were over one hundred separate macro's that controlled the simulation.

The programming involved very extensive testing. Many problems were detected during pretesting. No problems were encountered during the actual experiment.

3.4 Operationalization of Experimental Conditions: Independent Variables

3.4.1 Factor #1: Information Content - - ABC & VBC

Information content was identical in all situations except for the display of overhead costing. Overhead costs were either shown in "ABC" format or "VBC" format. The ABC format included the detailed costs for six overhead items that were associated with the production of each product. The VBC format summarized total overhead into one line, overhead. See Exhibit 90 for sample game results.

Total overhead costs were identical regardless of ABC/VBC format. Cost allocations among the four products were, however, not identical. That is the nature and advantage of ABC. ABC allocates costs more accurately. The popular "direct labor dollar" method was used for VBC allocations. The ABC condition used activity-based costing methods to allocate [the same] total costs among products. The ABC method gave an accurate allocation of overhead costs. Regardless of allocation among products, however, total overhead and therefore profitability was exactly identical using ABC or VBC.

3.4.2 Factor #2: Visual Presentation - - Graphs & Tables

The sales, cost and profitability resulting from each of the twelve years in each game were printed out [automatically] and used by the players for subsequent decisions. The results were given in two different presentations dependent on this second, presentation factor.

Results were either printed in numbers or graphs. (Exhibit 9.)

Players got a summary financial statement and cumulative listing of prior years' (within the current game only) results. This information was always numeric regardless of the presentation condition. The detailed, by product costing for the current year was given either in numeric format or in a graphic presentation. The graphs were simple bar charts.

3.4.3 Factor #3: Decision Framing - - Decision Bias

Framing bias is hypothesized to assist decision making. It should help with the less directed VBC information even more. Operationalizing this framing process is difficult. In fact the experiment originally sought to operationalize a different type of bias, confirmation bias. Confirmation bias would have had negative effects on decisions because the decision environment was going to be dynamic. This operationalization proved too temperamental or simply too difficult to adequately control. The decision environment was changed to static (within games). In this context a decision framework that adds focus to the decision process benefits the process.

To establish decision bias monetary incentives were used. Players assigned to this bias condition were told that if their verbalized (written) strategy was correct and they stayed with it that they would receive an additional $25 bonus for that game. They were also told that in fact if they met these conditions it would probably turn out that they had the best results in their group of eight so they would win the $100 top prize as well.

The potential $125 was considered to be strong incentive to provide focus and that this additional focus would aid in the decision making required in the static environment controlled by the given profitability functions. The players that were not assigned to this bias condition were told to verbalize their strategy as well but were offered no additional monetary incentive. The incentive provided the additional focus, the framing.

The bias condition was timed to be implemented after year five of each game. After the player made her choices for the fifth game and the results were printed, the computer automatically went to a section of the simulation that asked the players to take some time to think about their strategies through the first five games. They were then asked to write down the strategies, using the keyboard. The computer monitor showed the players their typed strategies, which they could revised as they wished (Exhibit 15). The positively "biased" players were told that their strategies might earn them an additional $25 bonus. The non-positively "biased" players did and had everything exactly the same except no mention of the $25 bonus was made [nor was it available].

Wicklund and Brehm (1976) and Church (1990) concluded that decision bias is stronger when people verbally commit to a position and when they choose that position themselves. The bonus serves to intensify the bias effect and thereby differentiate the bias group. Consideration was given to having the non-bias groups skip the verbalization step entirely. While this would certainly strengthen the relative bias, non-bias manipulation it would introduce a strategic confound that could not be properly distinguished from the bias effect itself. That is, the bias groups would develop formal strategies and the non-bias groups would not. Segregating the bias only effects from the strategy effects would not be feasible.

3.5 Response Variables

OBJECTIVE MEASURES:

1) The dollar amount of profit accumulated for each game.

2) The time taken to complete each game.

This research is directed at improved managerial decision making. This objective is undertaken by exploring the implications of improved overhead cost information and through understanding some possible cost communication avenues. The ultimate measure for business is wealth or firm value, and that is reached through firm profits. Experimental profits achieved are the ultimate measure of decision making. The value of information presented in the decision process is also measured in profits. Time is a secondary measure. Time is important as time is a constraint on managerial decision resources.

These measures are very conveniently operationalized in the experiment. Profit and time are straightforward. Profits earned in each game by the participants are measured as is the time taken to play each game. Profits [and time] in the worst year of play per game are eliminated as the participants were told it would be and were explicitly told to use one game as an opportunity to explore.

3.6 Covariate Possibilities

Demographic information was collected by the program during the instructional phase of the sessions. This included the participant's age, sex, SAT scores, grade point average, accounting area of interest, computer experience, accounting courses taken and other information (Exhibit 12). As mentioned in Section 3.3 spatial ability tests were also given to the participants.

This information was collected to look for correlation's with the response variables and to run ANCOVA's if the correlations seemed that they might affect results.

3.7 Pretesting & Simulation Development

Significant effort went into the computerization of the business simulation. The simulation and the operationalization of the experimental conditions was informally tested and challenged during many phases of development. This included work with the professors on my committee, presentation of the proposal to the Virginia Tech faculty and several presentations to schools during my job interviewing in the Spring of 1997. Many valuable insights were pursued as a result of this informal process.

A formal process of pretesting was performed once the model was built and tested to my initial satisfaction. The formal pretests were done using six student volunteers from my Cost One class at the University of South Carolina Aiken. Students were given extra credit for participating.

Students were set up, individually, with the computer, its self-inclusive instructions and told to "play the game." These conditions were exactly the same as planned for the actual experiment.

The game worked. It functioned from start to finish, completely automated and menu-driven, no operating problems! This was a major gratification. The students enjoyed it and got into a very competitive spirit when playing the games. That too was welcome. Pretesting revealed, among other things, one very "stupid" calculation oversight that a student brought to my attention. This simple finding was very important; profits were not accumulating properly in one of the games.

I also determined that the game, as originally designed with 16 years, was too long. Players seemed to be reaching a strategy well before the end of the 16 year games. Games were taking longer than I had wanted. I decided to reduce the games to 12 years.

A more sophisticated find was that two of the cost functions were too difficult. They were too unpredictable. I fixed that, but not without some difficulty. It was difficult to find a mix in cost functions that fell into a range that was both "do-able" yet not simplistic. Understand the cost functions were, taken together which is how the players dealt with them, much to complicated to actually understand. Yet, using an intuitive and trial and error approach a good cost function will provide ample clues to give players direction. This was the goal of my costing. My pretesting was very helpful in refining the cost functions.

As a result of my pretesting I found one significant program error, shortened the games to 12 years, improved the cost functions and made some cosmetic and explanatory changes to the program screens.

3.8 Statistical Methodology

Analyses: Results were summarized for analysis using the planned 2X2X2 mixed-factor design. ANOVA tests were performed to test all hypotheses using Minitab's 'Balanced ANOVA' procedure. MANOVA, ANCOVA and other statistical analyses were run as well

The experimental design was planned specifically to utilize ANOVA testing procedures. The three experimental conditions tested were easily differentiated into two categorical levels. All conditions were randomly assigned (Exhibit 17) to participants using Excel's random number generator. Condition operationalizations were rigidly controlled in a laboratory setting. Results are discussed in detail in Chapter 4.

Measurement: Forty-eight players participated in the experiment. Each player played four games, one of each of the four possible combinations for the two (two-level) within-subjects conditions. Twenty-four players were [randomly] assigned to each of the between-subjects conditions, and each played the combination of four games mentioned above. That totals to 192 game/observations in all. The game sequencing for each within-subjects condition was ordered such that all of the possible sequencing orders were performed (4 factorial combinations = 24). See Exhibits 4 and 20 for factorial combinations and sequencing.

Conditions one and two (content and presentation) were measured based on profits accumulated and time elapsed for years two through twelve for each game played, less the worst profits and longest time from one year for each game. Year one was not counted because the factors of interest were feedback conditions. Factor operationalization did not occur until after the first game. The first game provided feedback for the player (using the various conditions of interest) from which decisions were made[18]. The worst and longest years were not counted because the players were explicitly told in the instructions and reminded repeatedly during game play that their worst year would not be counted. The reason for this was to encourage some exploration by the players. Reasoning aside, the players were told this and results must recognize this. Players used this opportunity to experiment. One player tested the limits of the simulation and lost $172,000,000 in a single year.

Condition number three (framing bias) was not operationalized until after game five. Operationalization required the player to consider the game results to date (through game five) and set a strategy. The player was then either (1) given monetary incentive to stay close to that strategy or (2) was given no incentive so was free to flexibly adjust strategy as seemed appropriate. The incentive operationalized the framing bias. Obviously this condition had to be measured subsequent to the game five operationalization (games six through twelve). The worst year was also deducted from these results. Players were told to experiment with input for at least one game. In addition to the initial game instructions, a note at the bottom of each of their result reports reminded them that the worst year would be ignored. Finally, they were again told to experiment via instructions on their computer screen in year nine of each game. Year nine was in the middle of the framing operationalization period.

Time measurement was simply elapsed time between years. Graphic output took from three to four seconds longer to print than tabular output. Four seconds were deducted from the yearly times for graphic results. As graph play always took players longer than tabular play this approach was conservative.

Data Collections Procedures: The clerical process of data accumulation and summarization of results was processed in four steps. First, the game itself automatically saved all results from each player in a separate, protected excel file (Exhibit 18). This process was controlled by macros that were initiated by myself after each player finished each of the four games they played. Second, these 192 (4 times 48) individual result files were summarized into an analysis file (Exhibit 19). This file contained the demographic information for the players and their year by year results for all four games that they played. This file was used to accumulate and summarize further the results for the next analytical processing step. The third step extracted the summarized game information into Factorial Input sheets (Exhibit 20). Each input sheet contained the 192 response variable results needed to run one aspect of the desired analyses. (One input sheet for each of the response variables (profit and time). Several sets of these input sheets represented different analytic approaches.) The last processing step was to transfer the input sheet data to the Minitab Software program used to run the final statistical analyses (Exhibit 20).

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[18] Another reason to ignore the first year's result was that as the cost functions were changed for each game, player input for game one was essentially "blind." Results for game one were a matter of luck rather than knowledge.

All of these steps were performed using detailed controls to ensure proper data transfer. Control totals and data checking was done extensively. All transfers but step three were automated through the computer. Error messages were built into all the data transfers.

Exhibits 1A & 1B describe the experimental layout of the ANOVA summary tables. Exhibit 21 shows the actual Minitab ANOVA output. The results have been summarized into Tables presented in Chapter 4.

CHAPTER 4

Results

4.1 Overview

Results were mixed. I was interested in the effects that the three main effect conditions and their interactions might have on profit maximizing decision behavior. Two of the three conditions (content and framing bias) were found to have significant influence on the accuracy of decision making but did not affect decision time. The other condition (presentation) significantly influenced time but not accuracy. Aside from the message these findings have independently, this particular combination of main effect results provided interesting insights into the inter-relationships between conditions as well[19].

One of the three hypothesized interactions was significant. The significant interaction supported a narrowly hypothesized theory. In addition it required a very delicately tuned experimental design and worked very well within the theoretic pattern of the three separate main effect findings. For those reasons, the significance of this particular interaction was very well received.

Failure of the presentation condition to elicit significant differences for decision accuracy (profits) was a disappointment. ABC was the inspiration and the platform for this study. Significance for ABC was expected[20]. Truly, the thrust behind this study was not the singular ABC effects but the hoped for ABC effect differences given graphic or tabular presentation conditions. It was gratifying to have the timing differences register between graphs and tables, but the lack of profitability differences for graph and table presentation was discouraging. The presentation differences for profitability were so small that I did not even pursue alternative statistical techniques. There was simply nothing there.

Although my study did not show that graphic or tabular presentation yielded any differences in participant performance as measured in profits earned, the fact that graphic analysis took participants significantly longer time leads to the conjecture that under time constrained conditions graphic profitability might suffer as well. That conjecture was not tested; it remains conjecture, but it is both intuitive and interesting.

My study did show that within the confines of my setting (1) ABC information provides much better information in profit-maximizing decision making, (2) decision framing has beneficial effects on decision making, (3) decision framing is much more influential in

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19 A different combination of main effect results might have implied that the model simply did not pick up some effects adequately because of poor design. This particular combination of results that gives a pattern of effects for one response variable and a reversal of effects for the other indicates the model was a good differentiater.

20 Had ABC not been significant and had that non-significance been a true effect (not due to poor modeling) perhaps such a finding would have, in fact, been more noteworthy.

guiding poorly informed decision makers than those armed with better information, (4) the three aforementioned differences in decision quality come at no detectable cost in decision resources in terms of time, (5) presentation format did affect decision time, although it did not affect decision quality [for presentation].

Better information and framing yielded better decisions, but not faster decisions. Presentation did, however, affect time required to make decisions. Graphs took longer. The additional time required from the presentation format neither added to nor detracted from decision quality, however.

All of the significant differences represented truly meaningful differences. For example, the time differences for presentation modes were greater than ten percent and profitability differences were hundreds of thousands of dollars, within a range of, at most $ 1.2 million. Table 4.1 presents the average profitability and elapsed time results.

4.2 Discussion of Significant Findings

4.2.1 Information Content / Complexity: ABC vs. VBC

As expected players had better simulation profits when provided with ABC information than when they were given VBC information. Recall that the simulation costs were the exact same in total regardless of allocations, but individual product overhead costing was more accurately represented with ABC information. As a result product decisions were better supported by ABC information. Average profits for the ABC players were $213,038; the VBC players lost an average of $991,787. These differences were very significant (p=0.002). No surprise. The model worked very well indeed. ABC was very clearly a valuable decision tool.

As with real business, the model was barely tolerant of good decisions; profit earning potential was not large and operated within a somewhat restricted window. The model was most unforgiving of bad decisions, however. Poor decisions were slapped with large losses.

It took essentially identical times to make the good ABC decisions as the poor VBC decisions. This lack of difference could be a fault of the model design or it could be a result of offsetting influences. I do not know which. ABC information was more complex in terms of quantity of information so it should have taken more time to process. It may be, however, that players simply ignored some of the ABC details and focused directly on product profitability. To the extent that players bypassed the detailed ABC information in favor of the summary information, perhaps a more directed model would have helped elicit a timing difference. On the other hand the VBC feedback was more frustrating to players than the truer ABC feedback. Frustration can manifest unpredictable time effects. It can result in longer contemplation times in search of plausible variable relationships. Alternatively it can result in intuitive or guessing responses which are usually much quicker than reasoned responses.

It is remarkable that the timing responses were so similar. They were practically identical. Average game time for ABC was 16.97 minutes; average time for the VBC game was 17.16 minutes. The difference between the two is only .19 minutes, a difference of 1.1% (11 seconds).

In summary, hypothesis #1 that contrasted ABC cost information with traditional VBC information was confirmed for profits. The profitability performance differences were very significant: F = 10.45; p-value = .002. [See Table 4.1 for summary of statistical findings and Exhibit 21 for the detailed Minitab results.] Decision time was the same for both ABC and VBC.

4.2.2 Information Presentation: Graphic vs. Tabular

Graphs took longer to interpret than tabular presentation, but both presentations yielded similar game results [profits]. Cognitive processing of analytic information is task oriented. It was not known or predicted whether that task orientation would favor spatial or symbolic framing. Therefore in hypothesizing a presentation difference I did not feel comfortable in prediction the direction of the difference.

Ideal graphic presentation would encapsulate the cognitive message required for task solution. Properly designed this presentation enhances processing accuracy and lessens the time required for task completion. If the task is not spatially friendly the opposite occurs, problem solution requires more time and has worse results.

The experimental results indicated that graphic presentation added steps to mental processing rather than streamlined or focused processing. The graphs took longer to arrive at the “same” decisions. Since graph solutions were no better in terms of profits than tables it would seem that the graphs should have, and did, detract from problem solution. That this did not manifest itself in the profitability results is probably a result of the unlimited time allowed to reach decisions. It took longer and more effort to arrive at solutions given graphic input, but the eventual solution was the same regardless of presentation format. Had the decision time been limited it seems reasonable that this would have infringed on the quality of the graphic decision. This conjecture is plausible but was not tested.

Average game time for graphs was 17.88 minutes; average time for the tables was 16.25 minutes. The difference between the two was 1.63 minutes, a difference of 10%. The difference in profits between graphs and tables was a loss of $447,584 for graphs vs. a loss of $331,164 for tables. While these differences look large, the variances between individual players and games were very large. Thus these presentation differences in profits were not anywhere near significant. I can take a little [but not much] comfort in the fact that the direction -- unfavorable for graphs -- is consistent with the direction of the time effect, indicating that graphs were the poorer overall medium.

In summary, hypothesis #2 that compared graphic and tabular presentation formats was confirmed for time, but not for profits. The results were the reverse of the response variable findings for hypothesis #1 and #3. The time differences between graphic and tabular presentation were significant at F = 5.05; p-value = .029. [See Table 4.1 for summary of statistical findings and Exhibit 21 for the detailed Minitab results.] Decision profitability performance time was the same for both presentation modes.

4.2.3 Decision Framing Bias: Present or Not

The decision framing condition was based on sound theoretic hypotheses but was an ambitious operationalization. To design a methodology to capture response differences in decision quality based on decision framing was a delicate task. It was therefore particularly rewarding to find that framing significantly affected the quality of decisions made (profits). Importantly, the direction of difference held and the positive interaction effects (discussed below) also supported the theory that predicted the results obtained.

Players that were influenced to frame decisions made better use of the game information and made better decisions. It took them no longer or shorter to make these better decisions. The lack of elapsed time differences gives additional support for the hypothesized framing results, exactly as it did for information content (ABC/VBC). Had the framing players taken more time to reach their better profitability decisions it would be hard to isolate whether the beneficial effects were simply from the additional time taken in problem solution or were truly a result of framing. Since the decision time was the same for the framing and non-framing condition and all other factors were controlled at the same levels, the significant result can be attributed to differences in the framing condition.

The positively framed players made average profits of $102,246 while the uninfluenced players lost $271,670. It took 9.08 minutes for the positively influenced players to make their decisions versus 9.50 minutes for the uninfluenced players. Insignificant time differences, but once again the direction of the difference was as expected[21].

The insignificant time differences argue well for the framing operationalization method from another vantage as well. Execution of the framing condition included a monetary incentive that was not offered to the "non-framed" players. This procedure invites the speculation that observed differences could be the result of motivational changes. It would be possible that the financial incentive caused changes in motivation and that alone affected the results. Had the profitability differences been due to monetary incentives and motivation, however, one would expect that the financial incentive would have similarly motivated a more serious game approach that would also result in such players spending more time attempting optimization. That did not happen.

If we take the likely position that time spent is a reasonable proxy for motivation, then we can infer that players with the framing incentive were no more motivated that the non-incentive players. Further, the variances for the framing incentive group were much smaller than the group without the incentive. Standard deviations were $ 202,337 for the incentive

[21] Clearly time was not a factor in the favorable framing profits. Although time differences were not significant, average times were less under the framing condition.

group versus $1,654,584 for the non-incentive group. Smaller variances similarly supports successful implementation of the framing bias. Framing was designed to influence players to adhere to preliminary strategies in working toward final solutions. The fact that their decisions were better, their variances were smaller, yet their times were the same provides further evidence of framing was successfully operationalization.

In summary, hypothesis #3 that contrasted framing bias against a control for non-bias was confirmed for profits, but not for time. The profitability differences between framing and no framing were significant at F = 6.15; p-value = .017. [See Table 4.1 for summary of statistical findings and Exhibit 21 for the detailed Minitab results.]

4.2.4 Interactions

Main effect analyses showed strong profitability effects for information content (ABC was favorable) and framing bias (framing was favorable). The interaction between theses two influences was also significant [for profits]. Decision framing helped the VBC information group substantially more than framing helped the ABC information group.
Graphically this difference in degree of influence is shown as:

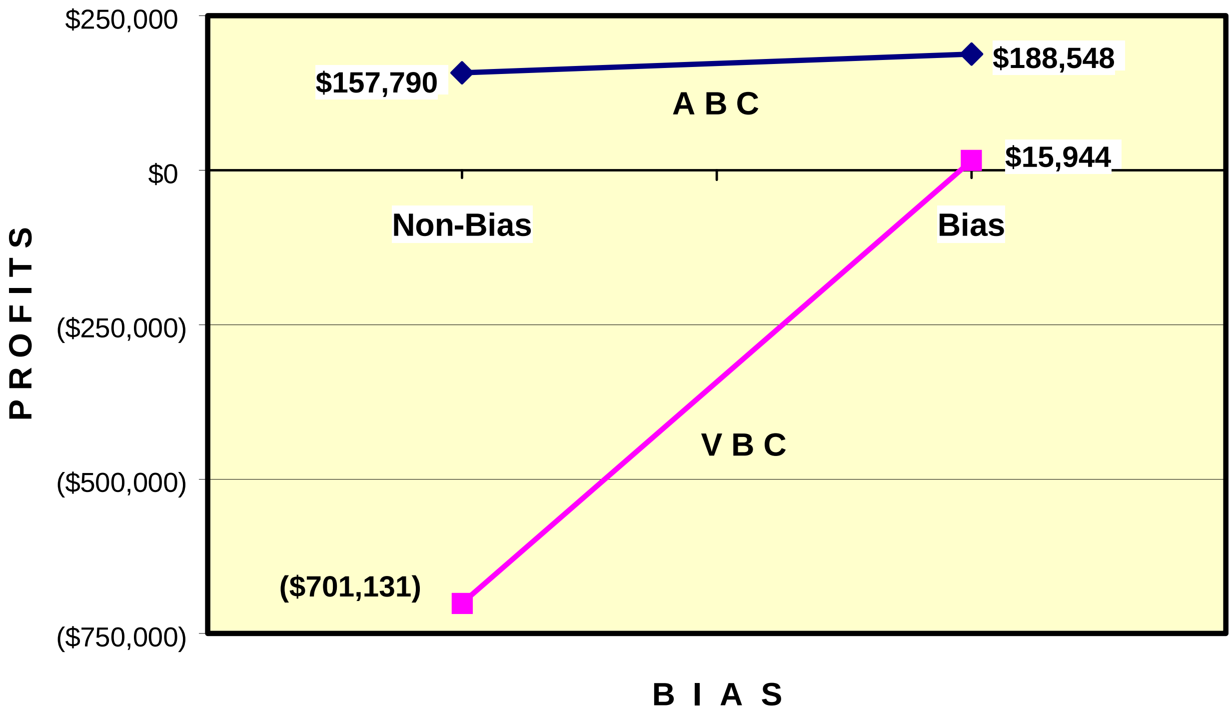

FIGURE 4.1 INTERACTION EFFECTS: COST INFORMATION AND BIAS

These stronger VBC Bias effects were predicted. Although the profitability and cost functions changed from game to game, within each game (12 years of play) the functions remained the same. Successful strategies were those that used yearly feedback to gain knowledge about the movement of the overhead cost functions.[22] Framing is valuable as it adds focus to the process. In the ABC environment that focus was of some incremental value (average profits moved from $157,790 to $188,548 under the added influence of bias) but not substantially so. In the more chaotic or less reliable VBC feedback environment players had a more difficult time understanding overhead cost behavior. In this situation the focus that the framing influence brought to the players analysis was very helpful. Average profits went from a loss of $701,131 to a gain of $ 15,944.

Once again decision times elapsed during the interactions did not vary significantly from condition to condition. As with framing as an individual influence, the lack of significant time differences adds support to the validity of the framing operationalization. The profitability or quality of decisions were different from condition to condition. But because decision times were essentially equal it seems that players were equally motivated. It was decision information and framing that appeared to directly affect decision performance, not a difference in motivation, potential financial incentive or analytical time spent. The difference was a result of the change in controlled experimental conditions, information content and framing bias.

The average times to complete games 6 - 12 (less the longest) was from 8.9 minutes to 9.6 minutes. In both the ABC and VBC cases the non-bias condition took longer than the bias condition. Bias framed the decision but didn't seem to add much motivational incentive (as measured in time elapsed).

In summary, hypothesis #5 that predicted stronger, positive framing influences with VBC cost information than with ABC information was confirmed for profits, but not for time. The profitability differences for the cost information and framing interaction were significant at $F = 5.18$; p-value = .028. [See Table 4.1 for summary of statistical findings and Exhibit 21 for the detailed Minitab results.]

<u>Other Interactions:</u> The other two interacting conditions, ABC / Presentation, and Bias / Presentation, showed no significant profitability or time differences. As noted, the presentation factor had disappointing results, both in main effect and in its interactions. Given that the presentation main effect was not significant it follows that the presentation interactions might be weak as well. The graphs did take significantly longer than the tables for players to process but no interesting spillover or interaction effects on the other conditions were evident. The players ended up with the same quality of decisions regardless of presentation -- the graphs just took longer. The interacting effects on time were consistent across conditions as well.

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[22] Players were told that all functions were linear except for overhead.

4.3 Results -- Summary Tables

The following table summarizes average responses for all the experimental conditions:

TABLE 4.1 AVERAGE RESULTS BY EXPERIMENTAL CONDITIONS

(See Table 4.2 for Mean Squares and Significance Levels)

Experimental Condition	Profits Earned	Time: Minutes
ABC Information	**$ 213,038***	**17.0**
VBC Information	**(991,787)***	**17.2**
Graph Presentation	**(447,584)**	**17.8***
Table Presentation	**(331,164)**	**16.2***
Framing Bias Present	**102,246***	**9.1**
No Framing Bias	**(271,670)***	**9.5**
Interaction -- Information & Bias*:		
ABC: No Bias	**157,790**	**9.6**
With Bias	**188,548**	**8.9**
VBC: No Bias	**(701,131)***	**9.2**
With Bias	**15,944***	**9.4**
Average For All Conditions -- complete games	**$ (389,374)**	**17.1**

Averages are calculated based on full game results (years 2 - 12 less worst) except for Bias Conditions and Interactions which covered years 6-12 less worst.

**Denotes significant effect -- (@ 5%);*

[t-test on ABC interaction component (profits), p=.38;
t-test on VBC interaction component (profits), p=.034;
t-tests for time showed no significance for any of the interaction components.]

The range of individual player responses was large. The game was very discriminating in awarding profits, but had extremely low tolerance for inputs outside its operating ranges. Accordingly losses were common and sometimes were high. The large range of results contributed to large variances which in turn made analysis of differences less discriminating than perhaps desired. From a practical perspective, however, those differences that were deemed significant were truly different. As evidenced by the above, no small, insubstantial differences were reported as significant.

TABLE 4.2 SELECTED ANOVA RESULTS

Hypothesized Effect	Response	Df	Mean Squares(*)	F Value	P Value
#1: Info. content -- ABC/VBC	**Profits**	**1**	**7.0 E+13**	**10.45**	**0.002**
#2: Presentation -- Graph/Table	**Time**	**1**	**127**	**5.06**	**0.029**
#3: Framing Bias -- Bias/None	**Profits**	**1**	**6.7 E+12**	**6.15**	**0.017**
#5: Content & Framing Interaction	**Profits**	**1**	**5.7 E+12**	**5.18**	**0.028**

~ ~ See Exhibit 21 for detailed ANOVA Tables from Minitab output ~ ~.

* Response variability for profits was large, as evidenced by large mean squares. The large variances accounts for the reason that some seemingly large differences in average response were not significant.

4.4 Other Statistical Procedures

In addition to using balanced ANOVA procedures and the t-tests on the interaction means, results were analyzed using several other statistical methods. This included ANCOVA, MANOVA, descriptive statistical measures, and correlation matrices. Non-Parametrics and regression models were run on a very limited basis as well.

None of the other procedures provided additional insights to existing conclusions.

This is not surprising. The experiment was designed and performed specifically to take advantage of ANOVA features. Had ANOVA failed to produce significant results perhaps non-parametrics, GLM procedures on data stripped of outliers, or covariance investigations would have been of value. Such pursuit was not necessary as the ANOVA results were quite satisfactory. Although I did run these alternative procedures, only ANCOVA provoked some interest.[23]

[23] As expected MANOVA had positive results. The next MANOVA step would be to look for univariate results (which tell a superior analytic story). Since I had univariate results, there was no point in pursuing the MANOVA further. Circular, yes -- but that's the way it was.

I collected information on eleven demographic variables. As the participants were all undergraduate accounting majors there was not a lot of subject variability. But gender, age, SAT scores, computer experience, and other information was collected as possibly being influential in terms of results. See Exhibit 16 and Table 4.3 for information collected.

Minitab (the computer) was not happy with my covariate model. I believe this was because of the mixed model I used. Minitab (the people) agreed with me that my model should produce valid results, but could only advise me how to adjust the model so that Minitab (the computer) would work satisfactorily. That model left out all the interactions except for the content/bias interaction that was significant. Terms with the bias condition were studied using the years 6 - 12 file; other terms used the full results file.

Using the years 6 - 12 file, only two covariates approached significance, spatial ability had the highest significance at p = .13 and sex had a covariate p value of .15. As covariates such p values are acceptable if they help to explain the hypothesized model. These two covariates did nothing to further explain the profitability results, however. Using these covariates the same significant effects [at alpha = 5%] were found, but they actually had higher exact p values than without the covariate. On the file for all years the lowest covariate p value was .28. Again nothing happened here.

I anticipated that I would get some action out of the spatial ability covariate. As evidenced by the relatively low covariate p values for spatial abilities some level of explanation was contained in the attribute, however, it had no real impact in adding to overall understanding of the factor relationships.

This covariate information is presented only as a matter of outside or peripheral interest. The balanced ANOVA provided excellent analytical results and needed no help. The non-parametrics (Krustal-Wallis), MANOVA, correlation matrices and regression analyses were also either duplicative or simply not of interest in light of the strong ANOVA results.

4.5 Demographics of Participants

Following is an analysis of pertinent demographic participant information:

TABLE 4.3 PARTICIPANT DEMOGRAPHIC SUMMARY

College Majors:	
Accounting	35
Accounting Systems	12
Non-Business	1
Year In College:	
Sophomore	1
Junior	41
Senior	4
MS-Accounting	2
Career Intentions:	
CPA/Auditing	7
CMA/Industry	11
Tax	3
Management	4
Consulting	12
Other	11
Computer Experience:	
None	0
Tech Required Only	20
Moderately Good User	19
Experienced User	9
Accounting Courses Completed:	
2 Principles Courses	48
Intermediate #1	8
Others	4

Economics Courses Completed:	
Principles One	47
Principles Two	46
Additional Courses	2
Grade Point:	
3.5 to 4.0	9
3.0 to 3.5	12
2.5 to 3.0	22
2.0 to 2.5	2
Below 2.0 or no response	3

	Average	High	Low
SAT Scores:			
Verbal	496	610	330
Math	597	760	400
Spatial Ability:	9.1	20	0

(Maximum score was 22)

Sex:

29 Females 19 Males

Chapter 5

Future Directions and Limitations

The Fall 1995 issue of the Journal of Management Accounting Research had seven articles. Three were on Activity Based Costing. First was a case study of General Motors' implementation of ABC from 1986 - 1993 (Anderson, 1995). The article reported on the implementation process and its benefits to GM. Next was the results of a mail survey investigating ABC implementation results for 143 companies (Shields, 1995). The focus of the study centered on business conditions associated with successful implementation of ABC. The success of ABC in terms of improved firm profits was touched tangentially in terms of management's level of satisfaction with ABC, but not directly. The final article (Swenson, 1995) surveyed 60 companies inquiring about management's satisfaction with ABC. Cost management systems improvements were noted..

While these articles are very important and do contribute much to the understanding of ABC, they do not do two things. First they do not, and no one has to my knowledge, establish an empirical conclusion whether ABC actually favorably affects firm decisions and therefore profits. Second they do not empirically and experimentally measure any of the behavioral conditions that may favor ABC implementation. We may have descriptive interpretations but not causality.

Other studies have experimentally compared ABC analytical effectiveness, but they did not look at the interrelationships between ABC usage and other decision influences. This study attempted to explore cognitive theory in an experimental setting to provide insight into when ABC information might be most helpful. Understanding the way that information users respond to information is essential to the accounting function. This study attempted to develop greater appreciation for how accounting ABC information was most productively utilized.

Intuitively ABC appears unchallengeable in providing superior information from which important, profit-dependent decisions can be made. To date descriptive research such as the survey's cited above seem to favor ABC. Yet, there is a growing backlash to ABC; and, yes, the "Japanese question" remains. This research has shown that ABC, if derived from appropriate cost drivers, unquestionably supports better experimental decision making. Decision framing also benefits decision making, but has significantly less influence on decision performance when the decisions are made based on the better ABC information than the VBC information. Framing helps the most in the weaker, VBC environment. Lastly, presentation medium affected decision efficiency in terms of time required to make decisions, but did not have any noticeable effect on the ultimate quality of the decisions made.

The failure to detect differences in decision quality resulting from alternative presentations (graphs & tables) was disappointing. While the model obviously was effective in capturing presentation differences, as evidenced by significant time differences, I believe the model needed more work in order to capture decision quality differences. While the graphs were the poorer communication medium, the graphs were sufficiently simple that they merely required more processing time by participants but were not actually so poor as to affect the ultimate decisions made. This finding is interesting in itself. Cognitive fit theory would predict synergistic findings: longer decision time implies a more complicated decision process which implies poorer decisions. Perhaps this remains true and my model just was sufficiently selective to elicit such responses. A more challenging graphic presentation might show significant differences in terms of graphic presentation weaknesses. This result, however, would be artificial and perfunctory. Yes, surely I could design a poor graphic medium. The challenge is, which would be especially rewarding in light of my present findings, would be to design a graphic media which was faster and better in providing for profit oriented decisions in an ABC environment.

The research findings and these limitations inspire the following possibilities for future research:

1. Replicate the entire experiment using Japanese or other Asian subjects. This would add a between subjects factor that could be integrated into the results of this study, yielding possibly extremely interesting two and three way cultural interactions. In addition the Japanese study as a stand-alone replication would have benefits similar to this research.

2. A connection between cognitive factors such as included in this research and the more practical based implementation factors included in Shield's research (see 1st paragraph of this section) might form a link between theory and pragmatic issues.

3. In addition to studying information complexity, format, bias and culture, an additional factor, group influence, could be included. This would match group decisions against individuals. The interactions, especially with the bias and culture features could be quite interesting.

4. Visualization factors could certainly be expanded to include more levels. Graphics can be remarkably varied. Human information processing is tremendously complex and humans are tremendously varied in response. These combinations yield many possibilities for study. As the factorial levels increase the results become harder to interpret and power is sacrificed, but with fractional factorial or composite designs that focus only on predetermined interactions these limitations could be controlled.

5. Study other response variables, such as the ability to identify trends, include user preference and user decision confidence. Consider a more cognitive response variable such as participant recall.

6. Add a fourth factor: define complexity in terms of a two product vs. four product optimization game. Either eliminate ABC/VBC as a factor or keep and use the two vs. four product simulation as another measure of complexity.

7. Test for graph vs. table decision making differences using a limited time to respond. This direction is in response to the current finding that given unlimited time, participants took longer to make decisions with graphic than with tabular presentation.

8. Look at covariate possibilities more closely. Covariate analysis did not add to the significance of the current findings, but some relationships were noted. A study of gender relationships might prove interesting. In addition, although spatial ability, as defined by the "Cube Comparison Test" did not prove significant this line or investigation should be pursued. Perhaps a different test of spatial ability or other cognitive learning attributes may be shown to be task related and therefore influential in performance.

9. Look at learning effects from two vantages: (1) year to year within each game and (2) learning from game one through game four.

10. Use all 2,304 yearly observations that were collected instead of the 192 summarized game observations. The yearly observations within the same game are not independent of one another, but could be analyzed by categorizing two new factors: Factor #4 = the game played (4 levels) and Factor #5 the year number within each game (12 levels).

The End

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