Research Reports

Man–Machine Planning Systems: A Cognitive Style Examination of Interactive Decision Making

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1. Introduction

A number of studies have appeared in recent years that deal with the influence of cognitive characteristics of decision makers upon the decision-making process. Among these characteristics, decision (cognitive) style has been the most carefully investigated. This research report describes a study which extends cognitive style considerations in a decision context to such factors of the decision process as information quantity and utilization and subject background.

Modern decision systems have become increasingly "interactive" and "conversational" in nature as a means of improving decision support. The study of man–machine decision systems by Scott-Morton [1971] and Gerrity [1971] emphasized the development of cognitive style-tailored systems for decision making. Such a development, although still remote, is an ultimate objective of my own research. However, the specific purposes of this study were: (1) to develop a basic methodology for researching the basic "human information processing" of decision makers; (2) to identify basic information utilization axioms for tailoring

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information for the decision maker; and (3) to use this methodology to investigate the impact of behavioral factors on the decision-making process. This investigation was carried out in a laboratory setting with students and businessmen.

Section 2 sets up the basic concepts to be used throughout the paper. Section 3 describes the methodology and measurement tools used for hypothesis testing. Section 4 displays the results obtained in the experiment. Finally, Section 5 summarizes what can be inferred from the result of the experiments, the methodological advantages and shortcomings, and makes suggestions for future research.

2. *Basic Concepts*

In order to explain the objectives and stated hypotheses of this paper, it is necessary first to define the main elements of an information system. Mason and Mittrof [1973] propose that an information system is composed of "... at least, a PERSON of certain PSYCHOLOGICAL TYPE who faces a PROBLEM within some ORGANIZATIONAL CONTEXT for which he needs EVIDENCE to arrive at a solution and that the evidence is made available through some MODE OF PRESENTATION."

The PERSON in this experiment is represented by surrogate decision makers (students and businessmen). The validity of student surrogation is discussed later in this paper. What is more important, at this point, is to establish the link between the PERSON'S PSYCHOLOGICAL TYPE and accounting information system designs.

A. BEHAVIORAL FACTORS IN MAN-MACHINE DECISION MAKING

Four basic areas are considered in this study as the main categories of behavioral factors in man-machine interaction: (1) cognitive characteristics (decision style, information utilization and processing); (2) communicational characteristics (perceptions, attitudes, inputs, and outputs); (3) emotional characteristics (frustration and fears); and (4) demographic characteristics (age, education, sex). While emphasis was given to the cognitive characteristics area, a selected subset of hypotheses related to the other areas is also included for methodological evaluation purposes.

Cognitive (perceptual) style refers to the way a person organizes information (Cronbach [1960]). Among earlier tests related to the measurement of cognitive (decision) styles were the "Water Jar" and "*Einstellung*" tests. "*Einstellung*" may be approximately translated as "mental set or orientation."

This latter test, slightly modified, was used by Huysman [1968] in the Heuristic/Analytic (H/A) test validation phase of his work. The simplicity of the H/A framework was considered both an asset and a liability. Its simplicity provided a well-tested and discriminating framework, however, the framework did not provide any context for extensive examination of cognitive processing of information. For this study, a

new test for cognitive style was designed and empirically tested (see Vasarhelyi [1975]). Its design and the hypotheses tested here were based on earlier research by Mock, Estrin, and Vasarhelyi [1972] and on descriptions of style behavior as presented by Huysman [1968]. These descriptions follow:

1. *Analytic reasoning*. This type of reasoning reduces problem situations to a core set of underlying causal relationships. All effort is directed toward detecting these relationships and manipulating the decision variables (behavior) in such a manner that some "optimal" equilibrium is reached with respect to the objectives. A more or less explicit model, often stated in quantitative terms, forms the basis for each decision. Factors not comprised in the model (e.g., because they could not be quantified) are considered only insofar as they may require significantly different courses of action than the one suggested by the model solution. Available alternative courses of action are also primarily valued in terms of the significance of their deviation from the model-proposed course of action.

2. *Heuristic reasoning*. A person using this type of reasoning emphasizes workable solutions to total problem situations. The search is for analogies with familiar, solved problems rather than for a system of underlying causal relationships, which are often illusory. Common sense, intuition, and unqualified "feelings" of future developments play an important role to the extent that they consider the totality of the situation as an organic whole rather than built up from clearly identifiable parts. It is extremely difficult, if not impossible, to uncover the mechanisms that lead to a decision under heuristic reasoning. If one has to characterize the resulting decision, however, it would be consistency of the decision with its internal and external environment as opposed to the optimality orientation of the decision of an analytic reasoner. (Huysman [1968, p. 51].)

Huysman [1968, p. 52] points out that these two ways of reasoning should be viewed as ideal types, forming the extremes on a cognitive scale or continuum. As one modification, communicational, emotional, and demographic data were included here primarily to provide a more complete picture of cognitive structure profiles. These data also enabled me to test various aspects of the methodology. Later, I intend to explore these added dimensions more fully.

Behavioral factors, with special emphasis on decision style, encompassed the PERSON and his PSYCHOLOGICAL TYPE involved in this research. The next section discusses the PROBLEM and ORGANIZATIONAL CONTEXT that were used.

B. A BUSINESS-PLANNING CONTEXT

The nature of the experimental variables considered and the decision support system used required a management-decision context (organizational context) with certain characteristics: it had to be of a general

nature, relying on both quantitative and qualitative data (nonbiased toward either of these), reasonably realistic, and of relevance to subjects. Given these specifications, I selected a planning focus.

The planning process was divided into six main steps: (1) objective setting, (2) problem formulation, (3) generation of alternatives, (4) evaluation of alternatives, (5) choice of alternatives, and (6) feedback. These steps are related to the ones prepared by Simon [1960] in a decision context. He divided decisions into two main types: programmable (structured) and nonprogrammable (nonstructured). Steps (1)–(3) are considered to be of the first type, steps (4) and (5) of the second, and step (6) of a mixed nature.

C. HYPOTHESES

The hypotheses were divided into three main areas: (1) behavioral hypotheses, (2) man–machine interface hypotheses, and (3) secondary hypotheses. Behavioral hypotheses deal with the different ways in which diverse, cognitively styled individuals make decisions. The second set of hypotheses relates experience with computers and specific machine features to various behavioral factors. Included were the attitudes of the subjects toward computers, along with the factors mentioned by Argyris [1971] as "human emotional factors." The third area relates certain background factors to behavioral and machine utilization factors. Table 1 provides an overview of the issues studied.

1. Behavioral Cognitive Hypotheses. The first area of concern encompasses hypotheses 1 to 7.

H1: Analytic decision makers will outperform heuristic decision makers in the structured part of the planning process.

H2: Heuristic decision makers will outperform analytics in the unstructured part of the planning process.

H3: In a well-balanced planning process, there will be no overall difference in performance between analytic and heuristic decision makers.

The unstructured, ill-defined initial steps of the planning process can perplex analytic minds, whereas heuristic thinkers will find it easier to deal with these problems. In contrast, heuristics will have more difficulties with the numerical problem solution steps than will analytics. Hypotheses like *H1* and *H2* were studied by Roy and Miller [1957] who investigated differences in decision approach based on varying backgrounds. *H3* is based on the rationale that a certain level of homeostasis governs a person's skills and that weaknesses in certain areas will be balanced out by strengths in other modes of thinking. These hypotheses are based on Huysman's descriptions and address the issues raised by both Mathes [1969] and Mock et al. [1972] related to quantifying the differences between Analytics and Heuristics along certain dimensions.

H4: Heuristics will use qualitative information more than analytics.

H5: Analytics will use quantitative information more than heuristics.

TABLE 1
Summary of Hypotheses Related to Behavioral Areas

Hypothesis number	Hypotheses area	Behavioral area	Focus	Target
1	Behavioral	Cognition	Cognitive Style	Performance
2				
3				
4				Information Utilization
5				
6				
7		Cognition-Communication		Decision Speed
8		Background-Attitude	Computer Experience	Role of the Computer
9		Background	Education	Performance
10	Man-Machine Utilization	Cognition-Emotional	Cognitive Style	Affinity for Computers
11		Cognitive		"Power" of Computers
12		Cognitive-Communication		"Flexibility"
13		Cognition-Emotional		"Difficulty With"
14		Attitude-Emotional	Attitude Change	Inclination Toward Creativeness
15		Attitude		
16	Secondary	Background	Sex	Performance
17			Recruitment	
18			Change	Information Utilization

If we consider that heuristics base most of their decisions on trial-and-error methods and "muddle through" to reach decisions (Lindbloom [1959]), their application of numerical data should be less intensive than the analytics.

H6: Heuristics will, on the whole, use less information than analytics. Analytic decision makers will be able to resort to the aggregate numerical data with much more ease than heuristics. Such reasoning is supported by the concept of channel capacity (Miller [1963]) and the limits imposed on the number of variables that an individual can control. Mock [1968] added support with his findings that heuristics will not try to employ all available information but will concentrate on a few key variables.

H7: Heuristics will make decisions faster than analytics. Although Mock et al. [1972] did not find significant differences between learning patterns of both styles, evidence supported the hypothesis that analytics took longer initially to make decisions, since they required some time to

develop their analytic models. Roy and Miller's [1957] results also support this hypothesis, showing that natural scientists were less redundant but took more time than social scientists.

2. Man–Machine Interface Hypotheses. Hypotheses 8 to 13 examine cognitive style and attitude changes in relation to user satisfaction, perceived power, system flexibility, and ease of using the system.

H8: Individuals with extensive computer experience will not change their perception of the role of computers in planning as much as inexperienced users. This hypothesis has implications of a normative nature for the recruitment and management of managers who will use interactive systems. A positive attitude toward MMDS is of extreme value in their utilization.

H9: The education level of the user is positively related to his performance as a planner. Users with extensive educational backgrounds will be more able to learn and therefore more likely to adjust to man–machine systems.

H10: There will be no significant difference between heuristics and analytics in their affinity toward the computer for planning. Since the man–machine system in question will be balanced with both quantitative and qualitative features, cognitive style will not be a differentiating factor of attitudes toward the system. The key determining factor for the utilization of MMDS's is management acceptance.

H11: Analytics will be less impressed than heuristics with the power of the computer as a decision aid. The availability of a tool that would enable heuristics to perform tasks that otherwise they do not perceive themselves as capable of performing would greatly impress heuristics.

H12: Heuristics will express more concern with the lack of flexibility of a man–machine system than analytics. Heuristics, because of their trial-and-error methods of problem solving, search in a larger environment for solutions and will feel more constrained by the computer than analytics, who are accustomed to looking to the available quantitative data as the means to the solution.

H13: Heuristics and analytics will have equal ease in using the man–machine system.

H14: Users can be positively influenced toward the use of man–machine systems simply by exposing them to a system with convenient interactional features.

H15: Attitudes toward creativity in the utilization of computers will be changed by practical utilization (as here).

Hypotheses 15 to 15 explored unique factors in man–machine interaction with the purpose of providing insights into those nonanalytic procedures widely accepted in the design of on-line systems. In addition to these, three additional hypotheses were tested to respond to issues related to the background factors of sex, recruitment, and information utilization.

3. Secondary Hypotheses. H16: There will be no significant difference [illegible] formed on sex. In the process of managing [illegible] for

the use of MMDS's, sex should not be an important factor.

H17: There will be no significant difference in performance between "volunteer" and "suggested" subjects. The literature of experimental research discusses extensively the mode of subject recruitment (Cunningham et al. [1974] and Abdel-Khalik [1974]). Subjects in this experiment were either part of a class assignment (suggested) or volunteers interested in the learning features of the experiment.

H18: Upon completing the experiment, users will perceive that they actually used much less information than they had expected to use. Miller [1963] suggests that there are limits on the number of variables a decision maker can control. Users would initially expect to use most of the available data in their planning decision process, but after participation in the experiment, it will be perceived that only a portion of the data was important in the decision process. This study is related to Miller's work in that it gives evidence of subject-perceived "channel capacity" limitations (see Chervany and Dickson [1974]).

3. *Methodology*

The methodology used to test these hypotheses was a laboratory experiment. Such an approach permits close monitoring of the subjects' decision processes as well as the manipulation of desired variables. Of course, simulated (laboratory) environments are not necessarily realistic and the generalizability of findings is often limited. However, the nature of the questions addressed provided no other feasible alternatives to a lab study.

Subjects were chosen from a large population of possible candidates. Due mainly to the long time required for the experiment (average 3.5 hours), only fifty subjects participated. These subjects could not clearly be classified either as "students" or "businessmen," since the prerequisite for participation was some exposure to accounting statements with some business experience as a desired second element. The average subject's business experience was 7.41 years. Recruitment was performed through the screening of candidates from classes which made participation mandatory if the candidate was selected and through an advertising notice of the "On-line Planning Course" to enlist volunteers.

The environment was simulated through the development of a financial planning case called "Thomas Industries," using a combination of three different Harvard Business School cases and the ten-year history of Phillip Morris Corporation as data. Such data were made available in the case as well as stored in the data base of the Interactive Planning Simulator (IPS).

The creation of a setting to perform the basic planning tasks, and the provision of comprehensible conversational features to interact with naive managers was accomplished by designing a hypothetical Interactive Planning system. Such a system was created with utmost care, after which a simplified Interactive Planning Simulator (IPS) was de-

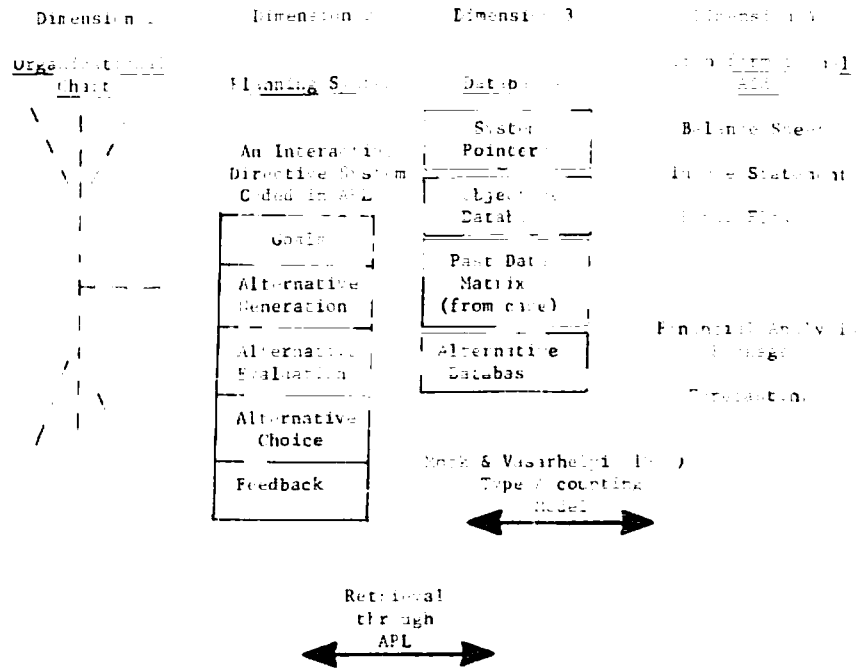

FIG. 1.—The interactive planning system (IPS).

veloped. This system, depicted in figure 1, is a surrogation of the Interactive Planner. It is composed of about eighty APL programs and utilizes the file capabilities of an extension of the APL system called APL Plus-File System developed by the Scientific Time-Sharing Corporation. A comparison between actual prescribed features of the Interactive Planner and the IPS is given in table 2.

The measurement problem in this research was of substantial significance and required the development of measurement technologies in information utilization and systems phenomena. The measurement problem concerning decision style was mentioned earlier and is discussed in more detail in Vasarhelyi [1975]. Unobtrusive measurements of systems utilization were obtained through traces of the subject's behavior built into the IPS. Measurements of information utilization were also obtained through tracing and pre- and postquestionnnaires. Attitudes were measured through the utilization of a semantic differential questionnaire (see Osgood and Suci [1955]). Finally, the measurement of planning performance by subjects was accomplished through the use of rankings of the quality of responses by judges and the development of the concept of "mean judge." Detailed discussion of the measurement tools can be found in Vasarhelyi [1973]. Further clarification can also be found in the later sections of this paper, which discuss the results of the hypothesis tests. An overview of the experimental design is given in table 3.

TABLE 2

IP versus IPS – Model versus Surrogate Comparisons

	Interactive planner IP	Interactive planning simulator (IPS)
(1)	Organizational data base	Data matrix
(2)	Data retrieval system	APL plusfile subsystem
(3)	Conversational features	APL conversational features
(4)	Object code	Interpreting each time
(5)	Hardware dependent	Hardware independent
(6)	Software library	Specific software packages for the selection of implementation features
(8)	Operational (if implemented)	Experimental

TABLE 3

Experimental Design

Step	Description	Explanation
1	Subject procurement and screening	Search for subjects, sign-up, phone contact and scheduling
2	Reception and instructions	Subject is placed in a quiet room and given introductory explanations
3	HA questionnaire	Subject responds to questions on pink questionnaire
4	Case	Subject reads the case
5	Prequestionnaire	Subject responds to questions on green prequestionnaire
6	Utilization instructions	Subject is given instructions on how to use the console and on the general features of the IPS
7	Utilization of the IPS	Using the IPS the subject formulates his planning decisions
8	Memo	Subject fills out the memo with his planning recommendations
9	Postquestionnaire	Subject responds to questions on blue postquestionnaire (forced choice and open-ended)
10	Debriefing	Subject is given an overview of objectives and features within the experiment

4. *Results and Data Analysis*

Specific results are summarized in table 4. All hypotheses are stated in the null form and are tested either by parametric or nonparametric statistics depending on the nature of the measurements. In cases where an argument could be made for either, the statistic with higher power was used. For more ambiguous situations, both types of statistics were used; fortunately, in these cases, the results were consistent.

All hypotheses related to cognitive style relied on the self-evaluation index as the indicator of cognitive style. This index is ordinal in nature, so nonparametric statistics must be used. Its measurement was a continuous scale between 1 (strongly intuitive) and 4 (strongly heuristic).

Anyone with ratings to the left of 2.5 was considered analytic and vice versa. A strict version of this measurement, considering only 1 and 4 (strongly analytics and heuristics), was adopted when the more general measurement was inconclusive.

A panel of judges was assembled to rank the plans submitted by the subjects and thus served as the basis for assessing the subject's performance. The initial step was the establishment of criteria for judging the plans. Following this step, each of the five judges independently ranked the forty-three subjects' performance. A Kendall W-test was run to test judge concordance and the result ($W = .619$) was significant at the 0.01 level through an F-test, indicating a high degree of agreement. The scores of the judge with highest individual agreement with all the others (the "mean judge") were used as performance measurements. This procedure avoided the questionable practice of aggregating rank data.

Such a measurement, ordinal in nature, requires nonparametric measures and the Mann-Whitney U-test was used to test whether the two groups had been drawn from the same population. Siegel [1956] calls this "one of the most powerful of the nonparametric tests. . . ."

Quantitative and qualitative (QTRI and QLI) information utilization indexes were developed by aggregating the ratings of responses given to questions in the information utilization questionnaires. An overall information utilization index (ORI) was also developed as an aggregation of the information utilization section of the postquestionnaire.

The analysis results of questionnaire data must be taken as tentative in nature as they used the subject's perceptions of actual information phenomena.

A. HYPOTHESES 1–7

It is useful to consider the results in the analysis of hypotheses 1 to 6 jointly. Note that four of these hypotheses were rejected (1, 2, 4, 5), and only two (3, 6) were accepted. The differences among the means were in the predicted direction, and if a .2 significance level had been adopted, all the hypotheses would have been supported. Later, I suggest that experimental problems (noise) might be a possible explanation for the lack of significance in the outcome of these hypotheses, and that tighter controls on the experiment could produce positive results in future experiments.

Hypothesis 7 considered the issue of decision speed. This variable was measured directly (and unobtrusively) through the conversation interval time of the user. These data are physical in nature and are clearly subject to ratio measurement.

B. OTHER HYPOTHESES

Hypotheses 8, 10, 11, 14, and 15 deal with MMPS user attitudes regarding the aid of computers, and were tested by utilization of a semantic differential questionnaire with "computers in planning" as the

TABLE 4

Summary of Hypothesis Tests

Description	Test results	Null hypothesis supported	Significance level	Stated hypothesis supported
(1) Analytics will utilize the structured part of the IPS to a greater extent than heuristics	t = .11 33df t = 74 11df (strict)	Yes	Not Significant	No
(2) Heuristics will utilize the unstructured part of the IPS to a greater extent than analytics	t = .12 33df t = .75 11df (strict)	Yes	Not Significant	No
(3) Analytics and heuristics will perform equally in planning	Mann-Whitney n_1 = 13 n_2 = 2_ u = 22 z = 7538	Yes	Not Significant	Yes
(4) Heuristics will utilize qualitative information more than analytics	t = 7066 Mann-Whitney u = 127 z = .330	Yes	Not Significant	No
(5) Heuristics will utilize quantitative information less than analytics	t = 1 186 33df	Yes	Not Significant	No
(6) Heuristics will utilize less information than analytics	t = 1 342 33df	No	1	Yes
(7) Heuristics will make decisions faster than analytics	t = .58 33df (general) t = 1 4 11df (strict)	Partially	Not Significant .1	Partially
(8) Experienced computer users will change their attitudes toward computers less than the inexperienced users	t = 1 34 3ldf	No	1	Yes
(9) There will be a positive relationship between education and performance	Spearman Rho = .295	No	.025	Yes
(10) Analytics will like utilizing computers in planning more than heuristics	t = 1 32 33df (pre) t = 1 14 (post)	No	1	Yes
(11) Analytics will be less impressed with the "power" of the computer as a decision too than will be the heuristics	t = 041 33df	Yes	Not Significant	No
(12) Heuristics will more often express their concern for the lack of flexibility of a man-machine system than analytics	t = 1 617 33df Mann Whitney	N	05	Yes
13 Analytics will have less difficulty in using the IPS than heuristics	t = 1 2[illegible] 3df	Yes	Not Sig[illegible]	No
(14) Exposure to the IPS will make users more inclined toward man machine planning systems	paired t = 5 51 40df	N	1	Yes

TABLE 4—*Continued*

(15) Exposure to the IPS will make users more aware of the possibilities of creative utilization of computers	paired $t = 2.773$ $40df$	No	01	Yes
(16) There will be no differences in performance related to sex	Mann-Whitney $u = 124$ $n = 54$	Yes	Not Significant	Yes
(17) There will be no differences in performance related to type of recruitment	Mann-Whitney $u = 206$ $n = 538$	Yes	Not Significant	Yes
(18) Individual users will utilize less information than their prior expectations.	paired $t = 4.597$ $40df$	No	01	Yes

target, seeking comparison of seventeen pairs of adjectives. Inverted pairs of bipolar adjectives were reverted and the summation of these ratings in the pre- and postquestionnaires were compared in order to evaluate changes in overall subject attitudes (*H8*). "Liking," "power," "inclination toward," and "creativeness" were drawn from specific questions of a semantic differential, either through a specific bipolar adjective or through the three main factors developed by Osgood and Suci [1955]. The three factors that composed a semantic differential space in the factor analysis of meaning were the following: evaluative, power, and activity.

A related hypothesis 12 (flexibility) was evaluated on the basis of open-ended questions using content analysis and the utilization of two judges who classified the answers and negotiated their disagreements. The results obtained were also supported by a weaker measurement which was the usage of the "flexible-inflexible" bipolar adjective from the semantic differential questionnaire.

Measures relating to other hypotheses were not deemed worthy of discussion. A summary of the results for all hypotheses is provided in table 5; note that twelve hypotheses were supported, and six were rejected. Of the six rejected, two seem to indicate totally opposite effects from those forecasted, while four were inconclusive, that is, they seemed to support the stated hypotheses, but not at a significant level.

C. POTENTIAL IMPLICATIONS

Overall, the results provide tentative support for the adequacy of the present methodology for information system studies. Two basic methodological questions that have been discussed again and again in the literature should be mentioned: trade-offs between parametric and nonparametric statistics and the usage of students as surrogates for businessmen. Concerning the first question, the strategy of conservatism in reporting was used, as was the utilization of the most adequate measure considering the scaling factors). Regarding the [illegible] issue this

TABLE 5
Hypotheses Testing Result: Overview

Hypotheses	Number	Result overview
Behavioral Hypotheses: Relating performance and cognitive style	1, 2, 3	Some support in that differences were in predicted direction but insignificant differences and less than adequate measurements for 1 and 2.
Behavioral Hypotheses: Relating cognitive style and information utilization	4, 5, 6	Differences in predicted direction but not significant for 4 and 5.
Behavioral Hypothesis: Decision speed	7	Supported for strict classification but no general classification.
Behavioral Hypotheses: Background	8, 9	Supported.
Man-Machine Utilization Hypotheses: Cognitive style	10, 12	Supported.
	11, 13	Not supported, evidence seems to support opposite effect.
Man-Machine Utilization Hypotheses: Attitude change	14, 15	Strong support for stated hypothesis.
Secondary Hypotheses: Background	16, 17	Supported the null and stated hypothesis.
Secondary Hypothesis: Miller's information utilization	18	Strongly supported.

study was oriented toward decision styles and attitudes in interactive decision making, and not toward a representation of a real businessman's behavior in corporate life. Therefore, in spite of not delving deeply into these controversies, the results seem to have at least limited generalizability.

The above results could be used to justify normative prescriptions such as: (1) Firms can hire highly educated managers of either sex. (2) Heuristic managers are more desirable in situations where information is expensive. (3) If an individual in a management position is experienced with computers and has a positive attitude toward them, he will utilize MMDS and tend to be satisfied with it. (4) Users (managers) who have only slightly negative attitudes toward computers before the utilization of an MMDS can be converted to liking them.

In relation to cognitive style, the results would also tentatively suggest that analytic decision makers should have interactive systems tailored to: (1) emphasize quantitative data, (2) allow more time for each interaction, and (3) facilitate interactive use.

In contrast, heuristic decision makers require tailored systems which (1) emphasize qualitative data, (2) are flexible in nature, (3) allow more interactions (less time required per interaction).

On a more theoretical level, the data indicate that there is a considerable difference between expected and perceived data utilization. Such findings are consistent with Miller's statements on the channel capacity

of the decision maker. This also points to a useful insight for a systems designer. Too much information is not useful and only obliges the decision maker to make a constant filtering effort. Also, cost-benefit considerations have to be made to decide on the ultimate desirability of tailored information.

As pointed out by Mock et al. [1972, p. 27]: "If decision approach is an important information system design variable, further research is needed to develop a taxonomy of relevant decision-maker characteristics. Certainly given the capabilities of modern computer-based accounting systems, individualized information systems are feasible."

The present study provides another step toward the development of a taxonomy of decision-maker characteristics. The next step will be the refinement of this taxonomy at an operational level, including other behavioral characteristics, which will facilitate the design of tailored information systems.

5. *Conclusions*

Table 5 summarizes the results of the hypothesis tests of this study. Regarding the overall study, areas of major interest are: (1) the methodological process presented; (2) the development of a further examination of cognitive style measurement tools; (3) the better comprehension in the human decision process of items such as quantitative and type of information for a specific decision style; and (4) techniques of measurement of attitudes and behavioral factors in man-machine decision making.

The main implication of the findings is in terms of the design of tailored management information systems specially suited to the specific manager's decision style. The results provide some support for relating design to decision style, but little can be said of a general nature. Moreover, the costs of doing so may exceed the benefits of improved performance.

The main shortcoming in this study was the weakness of some of the numerical results. This weakness was attributed to noise factors outside the control of the methodology. The computer system used was extremely unstable during the experimental stage, which led to the necessary elimination of five subjects from the experimental data and to the introduction of irritation and delays (by the subjects) during the experiment. Some software problems, undetected during the pilot studies and the experiments, caused the loss of some of the data which could have been used to cross-validate some of the critical measurements. Software factors might also have made the system somewhat too verbose; this could be corrected in further research. Finally, subject appreciation for the IPS might also have caused some noise problems as the subjects sometimes stayed on the system longer than necessary, "playing".

Further research, some in progress, advocates: (1) changes in the software system; (2) the adoption of a more discriminating cognitive

style framework (Driver and Mock [1975], (3) the adoption of a pre-run for each subject's adaptation to the IPS, and (4) the elimination of some of the stages of the experimental design by adoption of simplified questionnaires. Hypotheses being tested would replicate the ones already tested and extend further into the three behavioral areas not fully explored in this study.

Studies such as the one described in this paper are needed in Accounting Information Systems. They might be classified as basic research in a field that badly needs *basic research*.

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