Theodore J. Mock
University of Southern California
Miklos A. Vasarhelyi
Columbia University

Context, Findings, and Method in Cognitive Style Research: A Comparative Study

Research on human information processing in accounting has reached significant levels within the past several years. For example, the American Accounting Association [AAA, 1978] and Libby and Lewis [1977] surveyed the extant literature, and found substantial number of studies in this area. In addition, Libby [1981] links the area to the general category of behavioral decision making and quotes Slovic, Fischhoff, and Lichtenstein [1977] as having discovered more than 1,000 behavioral decision making articles which were published between 1971 and 1975.

The American Accounting Association [AAA, 1978] classified human information processing research approaches used by accountants into four major categories: (1) the Bayesian Approach, (2) the Lens Model Approach, (3) the Cognitive Complexity/Cognitive Style Approach and (4) the Process Tracing Approach.

A second set of literature surveys published in 1981 and 1982 [Ashton, 1982; Libby, 1981; Libby and Lewis, 1982] further examined this literature and also observed substantial growth. But these recent surveys tend to discount the value of cognitive style/cognitive complexity (CS) research. For example, Ashton [1982, pg. 8-9] argues that CS research "...has been criticized on several grounds, including the nature, measurement, and generality of the underlying constructs, the frequent failure to establish a link between the variables studied and measures of decision performance, and the absence of adequate criteria for evaluating decision quality." Ashton proceeds by quoting McGhee, Shields and Birnberg [1978] stating that "...personality variables do not appear to be useful in describing, understanding, or predicting human information processing."

Libby and Lewis [1982, pg. 272-273] treat the area somewhat more kindly:

> It would appear that the difficulties faced in the search for a direct link between personality or cognitive structure and decision behavior are more a reflection of the complexity of the relationships involved than a depreciation of prior research. ...recent applied research has demonstrated the need to search for more basic principles related to higher order mental processes

> such as research into the role of problem representation in learning and judgment e.g. [Tversky & Kahneman, 1980 and Einhorn & Hogarth, 1981].

This shift in focus and the suggested research emphasis is questioned in this paper, which reviews several experiments conducted in the 1968-1982 period. Each study analyzed dealt, to some extent, with cognitive style and decision making within simulated decision contexts.

More specifically, this paper summarizes a series of related experimental studies into information value and cognitive style. First, some previous studies are summarized, then a model that contains several key experimental variables is briefly developed. Subsequently, some new empirical results are presented. These results reflect the more complex, cross-contextual, analytic approach of two of these experiments which deal with alternative information structures and cognitive styles. The emphasis of this discussion will be on the three points raised by Ashton [1982] and a fourth additional one: Construct, performance measurement (diagnosticity), and decision quality and context.

PREVIOUS RESEARCH

In previous studies of accounting information, many methodological approaches and problems have been delineated. Subsequent discussion will detail some of the significant studies in this area. Particularly useful criticism of the cognitive style approach is found in AAA [1978] and Libby and Lewis [1982].

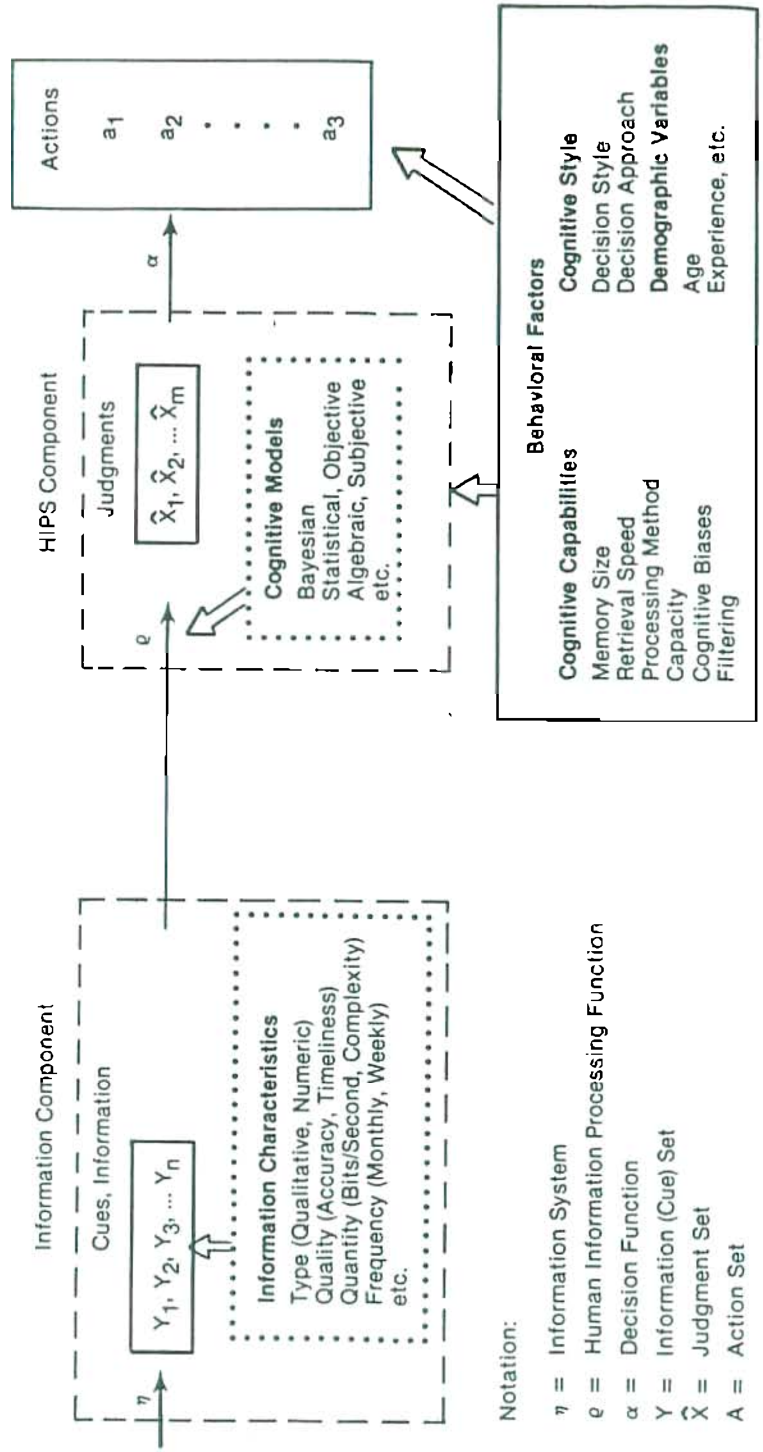
Within the realm of cognitive style, overviews are found for decision style and human information processing (HIP) in Driver and Mock [1975] and Lusk [1979]; for decision approach in Mock, Estrin and Vasarhelyi [1972] and Vasarhelyi [1977]; and for judgment in Ashton [1974a, b], Magee and Dickaut [1978], and Biddle and Joyce [1978]. The experiment examined in this paper considers a number a variables that are mentioned by Birnberg [1975]. Specifically, the interpersonal differences that are related to the degree of abstraction are contained in two cognitive style classifications (decision style and decision approach). These behavioral factors are evaluated with respect to information structure variables that are experimentally controlled.

Some of the relations among these variables are presented in Figure 1, which is designed from an information systems perspective. In the figure, cues are considered to be those characteristics controllable by the accountant. Research into both cognitive models and behavioral factors is justified if it demonstrates that models of human information processing can be used to improve information system design.

Figure 1 includes a number of behavioral factors that have been shown to have a significant effect on information processing. For example, the literature in cognitive studies and artificial intelligence indicates different behavioral constraints including serial processing, limited short term memory, overload, processing constraints [i.e., Miller, 1956], and Weber's law of just noticeable differences. Research in psychology has identified a number of related behavioral factors such as anchoring, the representativeness heuristic, inconsistency and leveling [see Slovic, 1972].

FIGURE 1

Model of Information
Human Information Processing and Behavioral Factors



Other studies have suggested ways of dealing with some of these variables. For example, Birnberg [1975] notes that many techniques have been developed in accounting, mostly through trial and error, for coping with information overload. Among these are techniques of aggregation, precalculation, and unfolding of the data via a general description, followed by a graphic display, then aggregate financial statistics and so on [see Casey, 1981].

A number of accounting studies have experimentally investigated the relationships between information variables, behavioral factors and performance. For example, Casey [1981] examined bank loan officers' bankruptcy predictions and found no improvement in predictive ability and a substantial increase in decision time when a financial footnote was added to the available information. Chervany and Dickson [1974] tried to measure overload situations experimentally by comparing two groups of students, one given statistically summarized data and the other raw data. In addition to this overload factor, concepts such as filtering of information, quantity of information, type of information, and aggregation of information have been noted in the literature as being important HIP factors. Other variables, such as experience, time pressure, effort, and motivation are also pertinent.

Let us first address the issues raised by Ashton and an additional one (context) which is of equal importance as shown in the literature in other areas [Wright, 1975].

Construct

Ashton's first question concerns the nature, and thus the validity of the underlying constructs of CS research. This question can be examined in terms of a framework designed to aid in the prediction of a particular behavior or to segregate individuals with similar traits. If this CS construct has discriminating ability (e.g. predictive validity), it can help in the understanding of human decision processes by providing a means for clustering different decision approaches.

Diagnosticity

Ashton's second concern has been referred to in the literature as diagnosticity, which relates to the linkage of the decision variables and performance. Most decision analysis contexts should specify: (1) States of the world, (2) Information, (3) Judgments, (4) Actions, and (5) Outcomes [Mock and Vasarhelyi, 1978]. However, in the social sciences the observed relationships between information (a soft and often public good) and outcomes are often statistically weak and interdependent. For example, accounting information and bankruptcy prediction, gathered audit evidence and audit opinion, and accounting information and security prices are all linked by solid logical reasoning but weak empirical relationships. These statistical findings are further confounded by the nature of the measurement used to capture the information and the choice and quality of outcome measurement. Additionally, the linkages between judgments and actions are poorly specified and entail further study. Finally, management actions have a stochastic relationship with outcomes. The chaining of a series of stochastic relationships from the states of the world to final outcomes results in weak statistical linkages.

At this stage of basic research, the intermediate steps (1) between the states of the world (X) and the information set (Y), (2) the information set and judgments (X), (3) judgments and actions (A), as well as (4) actions to the set of multiattribute outcomes (O) are tenuous. Therefore, in testing for categories of individuals (C_1, C_2, $\in C$) where each C_1, C_2 etc. refers to a discrete decision style that would lead to different sets of outcomes, we have a comparison:

$$o_1 = f(x, \hat{x}_1, y_1) \text{ for sub-population } c_1$$

and

$$o_2 = f(x, \hat{x}_2, y_2) \text{ for sub-population } c_2$$

where c_1 and $c_2 \in c$.

In addition to the measurement problems regarding the relationships of 0, Y, $\hat{X}$ and X, there are inherent psychometric limitations in discriminating among the measures of cognitive style.

Decision Quality

Ashton's third concern is with the difficulties inherent in the measurement of decision quality. Business decisions and outcomes are often multiple objective, multi-attribute phenomena and yet they tend to be evaluated on one dimension with a limited set of states of nature. For example, bankruptcy tends to be judged via the filing or not filing for Chapter 11 status; audit judgment by the issuance of a clean versus a qualified opinion; and, stock selection through limited period portfolio gains and losses. These simplifications lead to a substantial weakening of the relationships between 0 and the multi-attribute state-of-the-world $x_{i,j,t}$ (the states of the world for attribute i, in relation to objective j in period t).

Context

Basic research into the natural and physical sciences can take decades to be incorporated into everyday life. The questions concerning generalizability, then, are perhaps misleading, and more probably premature, as basic research into human information processing cannot be expected to immediately be applicable to a wide set of problems. Unlike the physical sciences, the social sciences are confronted with a large set of confounding variables.

There are still very complex issues concerning measurement and context validation that have not been addressed. Of particular concern is the measurement of cognitive style which has been commonly addressed by tools from psychology that were developed mostly with general human behavior predictors and classification in mind. It is likely that measurement could be substantially improved with psychometric—based, but information evaluation—oriented, classifications.

Marketing studies [Wright, 1975] have indicated that buyer behavior, for example, will be substantially affected by the marketing problem being considered. This same effect is probable in accounting settings. For example, it is likely that different information structures will prevail in stock purchase decision than in budget variance evaluation decision. Therefore, basic cross-contextual research in this area may help capture the most common effects and control for context-dependent phenomena.

In summary, the four above issues do not negate the value of cognitive style research but instead serve to attenuate researcher explanations concerning explanatory levels that can be attained. In addition, these four issues suggest a cross-contextual approach for research design and data analyses. These topics will be further discussed in the remainder of this paper vis-a-vis a series of experimental results.

The experimental research reported in the following sections is directed at the measurement and evaluation of some of these variables and the interdependence between information system design and behavioral factors. While much research has been conducted on these topics, further comments in this paper will be restricted to our own experimental studies. First, a summary of previous studies will be discussed, followed by a presentation of the results of our most recent experiments.

SELECTED STUDIES AND FINDINGS

An overview of previous studies is presented in this section to facilitate an understanding of the longitudinal aspects of the research, to help demonstrate some of the methodological difficulties and enhancements that have occurred, and most importantly, to present some new interpretations of previous results from the standpoint of human information processing. Within the span of the research, four major types of experimental settings (decision contexts) have been used. In each case, a business or economic decision model has been incorporated within a controlled experiment. Table 1 summarizes the methodological differences within each decision context.

The Experimental Settings

Four versions of the Information Structure experiments (denoted IS1, IS2,...) have previously been conducted. The IS setting is unique in its emphasis on controlled information differences and their underlying structure. Complete description and documentation for these experiments can be found in Mock [1969] and Mock and Goodfried [1975].

The second decision setting involves a more intricate forecasting problem and a more complex information and decision support system denoted as the Interactive Planning System (IPS). Rather than researching specific information differences, the IPS experiments emphasize the combined effects of cognitive style (specifically analytic versus heuristic *decision approaches*) and the type and amount of information utilized. A more complete description of IPS may be found in Vasarhelyi [1973].

The third decision context utilizes a Simulated Stock Exchange (SX) run under three specifications (SX1, SX2 and SX3). The cross-contextual research results reported in the following section involve IS4 and SX1. Like the IPS methodology, the stock market simulation emphasizes information utilization and cognitive style differences. But unlike IPS, normative decision models such as portfolio models can be referenced to evaluate performance differences.

The fourth decision context utilizes the Accounting Data Analyzer (ADA). ADA requires that an interactive portfolio choice decision be made using a three stock context. This version of a stock market setting (where a maximum exists) is highly structured and monitorable. Automatic traces of information accessed and information regarding the duration of utilization are gathered, allowing for a simplified version of process tracing. The ADA experiments, unlike their precedents, use a cognitive style and information structure matching design whereby subjects are given cognitive style tailored information systems. These "tailored" systems supply users with their "preferred" levels of data aggregation and information type. Subjects are also given, on a random basis, "counter-prescriptive" systems that are tailored to the preferences of the opposing cognitive style.

Each experiment in Table 1 has dealt in some way with cognitive style. The distinction between decision approach[1] (analytic versus heuristic) and decision style[2] (decisive, flexible, hierarchic, and integrative) lies in the complexity of the underlying behavioral models. Part of the current research involves an evaluation of various cognitive style models and measurement tools.

Summary of Previous Findings

Table 2 provides a summary of the major findings of each of the previous experiments. The results are classified according to the cognitive style variables analyzed in the study. The blanks in the table indicate that the variables in question were not evaluated in the particular experiment.

Three overall results are of interest. First, significant information structure effects have been observed in every applicable case. Of particular interest with respect to information structure effects is the interaction between information structure and decision style observed in IS3 [see Driver & Mock (1975)]. Herein lies some of the first experimental support of the impact of tailored information systems. These findings were pursued in the ADA experiments via the cognitive style tailoring of the information systems.

The second area worthy of attention concerns the results that have been obtained with respect to cognitive style. Neither the decision approach dichotomy nor the decision style model have led to consistent, unambiguous results. In many cases, the overall variance is not explained to a significant degree. However, there are some encouraging results, such as the tendency for the decision approach dichotomy to predict type of information utilized, and the general discriminatory ability of the decision approach construct with respect to decision time, learning pattern and information comfort.

The third main observation regarding HIP research concerns information processing results obtained in IS1 and IS2. In this particular decision setting, normative information-decision rules were derived and a weak, but statistically significant, relationship between decisions and available cues

TABLE 1

Classification of Experimental Settings (Decision Contexts) For the Accounting Simulation Experiments

Experiment Name	Decision Setting and Rule (α)	Methodological Differences: Information System (η)	Information Utilization (ρ)	Behavioral Factors (B)
Information Structure (IS) Experiments	Highly Structured Micro-economic Game, Optimizable	Controlled Differences (Timeliness, Coarseness, Completeness)	Specific Information Processing Rules Tested	Decision Approach, Decision Style
Interactive Planning System (IPS)	Unstructured Financial Planning Case, Not Optimizable	Single Structured Planning System	Measures of Type, Amount of Information Used	Decision Approach
Simulated Stock Exchange (SX) Experiments	Capital Stock Market, Theoretical Decision Models (i.e. Portfolio Theory)	Not Controlled	Measures of Type, Amount of Information Used	Decision Approach, Decision Style
Accounting Data Analyzer (ADA)	Structured Stock Selection Setting, Optimum Available	Prescriptive, Counter-Prescrip. or Neutral	Information Usage Training, Times and Decisions	Decision Approach

was observed. Actually, these relations are composite information processing and decision functions. The important differences between this approach and the Lens model approach [e.g., Ashton (1974c)] should be apparent. In most research utilizing the Lens model, a hypothetical or normative relation between cues and decisions or judgments is not derived. Thus ANOVA and correlational models are used to estimate, but not test, precise theoretical relations. In contrast, in more structured decision situations, such as IS and SX, normative decision theory can be used to postulate information processing and decision functions, and to test the various HIPS models.

The previous experiments have generated some evidence on the relationship between information utilization and cognitive style. For example, the IPS results indicated significant cognitive style related differences in the amount of information utilized. Also, when cognitive style was classified in terms of decision style, significant differences in decision times were observed in IS3. This was taken as being indicative of differences in the amount of information processed.

TABLE 2

Summary of Prior Research

	EXPERIMENTS			
Experimental Variables	IS1 Mock 1969	IS1a Mock et al 1972	IS2 Mock 1973	IPS Vasarhelyi 1973
Cognitive Style—Decision Approach	—	First Study Using Decision Approach	—	Significant Differences in Information Utilization (Quantity)
Cognitive Style—Decision Style	—	—	—	—
Result	Optimal Information Processing Rules Significant	Performance Learning and Decision Approach Effects	Optimal Information Processing Rules Not Significant	Miller's Hypothesis Supported
Primary Focus of Experiment and/or Analysis	Methodology, Value of Timely Information	Effect of Decision Approach	Value of Budget Information	Tailored Decision Support System, Information Utilization

TABLE 2 (continued)

	EXPERIMENTS			
Experimental Variables	IS3 Driver & Mock 1975	SX1 and IS4 1976	SX2 and SX3 1979-80	ADA 1981
Cognitive Style—Decision Approach	—	Significant (Pre-Test) Differences Information Type and Quantity Preferences	Regression Modeling of Decisions Made Across Cognitive Style	Differences in Information Preferences - Aggregation - Type Style
Cognitive Style—Decision Style	Significant Decision Speed Effects	Significant (Pre-Test) Differences Information Type and Quantity Preferences	Significant Pre-Post Attitude Change	—
Result	—	Optimal Information Processing Rules Significant but Individual Differences Dominant	Relationships Between Decision Approach and Decision Style	—
Primary Focus of Experiment and/or Analysis	Decision Style Theory Tailored Accounting Feedback	Cross-Contextual Methodology, Cognitive Style, Information Value	Cognitive Style Information Utilization	Cognitive Style Tailoring of Information Systems

Overall, the previous experiments have provided some tentative results for researchers interested in information structure and human information processing analysis. Although these results are derived from three different settings, no particular variable has been evaluated in an ex ante, multiple setting (cross-contextual) design. The results reported in the next section do take advantage of an ex ante, cross-contextual design for both cognitive style/performance and cognitive style/information perception analyses. By presenting identical subjects with different tasks, the generality of any findings should be enhanced. This type of research approach may be viewed as addressing some of the context and generalizability issues raised earlier.

A CROSS-CONTEXTUAL ANALYSIS

Experimental Setting and Method

This section describes the results of two experiments (IS4 and SX1), as analyzed under a cross-contextual framework. The two settings encompass a micro-economic and a stock market game (see Table 1). These contexts provide measures of subjects' performance and their attitudes toward the type and quantity of information available during the experiment. Two independent variables are analyzed: type of information provided (information structure) and cognitive style. The discussion begins with a description of the experiments. Specific hypotheses and their underlying justifications are incorporated within the presentation of results.

The IS4 experiments used a population of 130 graduate business students and a 2 by 2 factorial design. The IS4 setting involves a multiple-decision, multiple equation game. Subjects are asked to read a case and make decisions concerning advertising, quantity to be produced and materials input used. Additionally, subjects are asked to prepare a budget for each decision period. These decisions are then entered into the model through a computer terminal, with subjects receiving different modes of feedback for that period. Following this feedback, they make their next decision. This cycle is repeated several times before the completion of the experiment (three hours or ten decision periods). The controlled or experimental variables in this factorial design are the *coarseness* of the feedback information and the *completeness* of budget variance information.

The SX1 experiments are based on a hybrid stock market game. The simulation used current stock market prices of 50 New York Stock Exchange (NYSE) stocks that could be traded by subjects. A detailed description of the setting may be found in Vasarhelyi et al. [1981].

Ninety-seven of the 130 MBA students who had completed IS4 participated in the SX1 experiment. All transactions were monitored by means of a transaction form. Biographical data and pre-test and post-test attitudes concerning the stock market and information utilization were obtained through questionnaires. A computer system kept track of portfolio situations and issued bi-weekly reports.

For both experimental contexts, cognitive styles were measured by means of the self-evaluation questionnaire [decision approach, Vasarhelyi, 1977] and the IST test [decision style, Driver and Mock, 1975]. One of the initial concerns was whether these two tests were measuring independent or interdependent classifications of cognitive style. As the definitions of analytics and hierarchics are quite similar [see Mock et al., 1972 and Driver and Mock, 1975], a significant correlation among the classifications was hypothesized. In order to examine these effects a 2 x 5 factorial design was used for analysis. Table 3 classifies the subjects who took both the self-evaluation questionnaire and the IST test into the cognitive taxonomies. These data indicate a weak but definite relationship ($\alpha = .076$) between the two taxonomies. In the analysis, hierarchics tended to be classified as analytics and integratives as heuristics. As these results are consistent with the construct definitions of each classification, a degree of construct validity was provided here.

TABLE 3

Classification of Subjects By Decision Approach and Style (Frequency and Percentage)

Decision Approach	Decision Style D	F	H	I	C
Analytic	8 8.3%	12 12.5%	10 10.4%	6 6.3%	10 10.4%
Heuristic	15 15.6%	10 10.4%	4 4.2%	14 14.6%	7 7.3%

Statistics

Chi Square = 8.46

Significance = 0.076

Uncertainty Coefficient = 0.07 (with D/A dependent)
= 0.03 (with D/S dependent)

Notation

D = Decision
F = Flexible
H = Hierarchic
I = Integrative
C = Complex
D/A = Decision Approach
D/S = Decision Style

Cognitive Style Effects

One of the three basic areas researched in these experiments concerns cognitive style effects (see Figure 1). The primary interest in these effects stems from the implication of a potential for tailoring accounting systems, and other aspects of decision making, to the cognitive style of the decision maker. Our initial analyses considered the relationship between decision style (D/S), decision approach (D/A), and the subjects' performance within each experiment. This was designed to answer questions such as: "Is cognitive style a determinant of performance?" The analysis then continued to seek information concerning the subjects' perceptions of the type and availability of information.

Table 4 summarizes some of the cognitive style analyses that were performed. Both models of cognitive style were analyzed. The *Decision Approach* partitioned subjects into analytics (A) or heuristics (H), while the *Decision Style* theory used the decisive (D), flexible (F), hierarchic (H), integrative (I), and complex (C) decision styles.

The analysis in Table 4 shows the effect of cognitive style on performance, type of information preferred, and perceptions concerning quantity of information. The measurement instruments used for decision style and decision approach, their validity and reliability have been discussed in the references cited earlier. However, the consistency and predictive ability of such instruments remains a concern. As cognitive style was determined in an ex post facto manner (subjects were placed in an experimental setting and later tested on their cognitive style), the resulting design was a factorial analysis with unequal cell frequencies (see Table 4).

TABLE 4

One Way Analysis of Cognitive Style Effects

Performance		Decision Approach A (56)	H (51)	F-Value	Decision Style D (22)	F (22)	H (16)	I (25)	C (17)	F-Value
IS4: Profits (in thousands)		102.4	109.7	n.s.	111.0	98.9	113.1	101.0	104.0	n.s.
SX1: ROI (% of Investment)		6.4	4.8	n.s.	5.5	6.9	7.4	5.9	5.6	n.s.
Information Perceptions										
Preference for Quantitative Data 1) (SX1)	PRE	45.7	36.3	2.8	47.9	45.7	32.7	29.2	44.4	1.86
	POST	44.8	38.5	n.s.	41.8	45.9	34.5	36.6	45.6	n.s.
Preference for Qualitative Data 1) (SX1)	PRE	37.3	46.9	3.1	40.2	24.2	45.9	50.7	46.2	2.2
	POST	43.8	52.7	2.4	47.9	48.2	52.7	54.6	45.3	n.s.
Information Sufficiency 2) (SX1)	PRE	3.84	4.08	n.s.	4.1	4.4	3.4	3.8	3.9	n.s.
	POST	4.43	4.23	n.s.	4.0	4.9	4.6	3.6	4.5	3.2
Information Quantity 3) (IS4)	PRE	4.11	3.45	5.6	3.5	3.9	4.7	3.5	3.5	2.1
	POST	4.33	4.00	n.s.	3.6	4.7	4.5	4.2	4.2	2.1

1) What type of information did you use in making your trading decisions (in relative percentages)?
Quantitative? Qualitative? Other (specify)?

2) Do you feel you had enough data to make your decisions? (Too little = 1, Too much = 7)

3) Please rate the absolute amount of information in the experiment. (Very little = 1, Very much = 7)

Performance Effects

Both simulations used aggregate performance measures. For the IS4 experiments, average period profit was used. In SX1, performance (ROI) was computed as a function of stock portfolio value change, dividends received and interest earned by the investment of unused cash balances in government securities.

A priori, differences in cognitive style were not expected to result in performance differences. This should hold true for either task, especially under the stock market scenario used.

> H1: Differences in cognitive style are not expected to result in significant performance differences in either decision task.

This hypothesis was tested using a one-way ANOVA for each cognitive style and decision approach. The results show that in neither case was cognitive style a discriminating factor vis-a-vis subject performance. Although the overall averages are not significant, a comparison of these results with previous versions of IS is of some interest. In fact, many of the results for both D/A and D/S are contrary to previous findings. For example, while analytics outperformed heuristics in IS1, IS4 shows the opposite tendency. Also note that the decisives performed well in IS4 whereas the overall profit performance was by far the worst in IS3.

Note also that the IS4 and SX1 contexts show similar results, giving more credibility to the experimental findings; therefore, cross-contextual designs may serve to better assess relationships that are theoretically expected to be difficult to measure.

Self Perception of Type and Quality of Information Used

> H2: There will be significant differences in the type of information being used by individuals with different cognitive styles.
>
> H3: Cognitive style differences lead to different perceptions of the need for and usage of information.

These hypotheses are based on the findings by previous studies such as Vasarhelyi [1977], and the theoretical specification used regarding the nature of individuals with different decision styles. The cognitive style framework [see Driver and Mock, 1975] uses as one dimension of its classification grid the variable quantity of information used for decisions.

Information was divided into two major types: quantitative and qualitative. Analytics are expected to focus on quantitative information while heuristics are expected to focus on qualitative. Vasarhelyi [1977], using a planning framework, tested for information type. In this paper we examine information type in both the IS and the SX settings.

Quantity of information is an extensively explored topic. It is connected to issues such as content of information and information overload [Chervany and Dickson, 1974; Dickson, et al., 1977]. The attempts to relate information quantity to cognitive style is a natural extension of these studies. Conclusive results in this area can be of major importance in the tailorization of information systems.

SX1 tested the subject's perception of his usage of quantitative and qualitative information in the simulation. One of the questions requested subjects to break down the type of information they used (or expected to use) between quantitative, qualitative and other, using a 100 point fractionation scale. Additional questions asked subjects to rate on a Likert scale (from 1 to 7) the importance of these types of information. The correlations among the fractionation measures and the corresponding Likert scale ratings were high, and all were significant at the 1 percent level. Given these high correlations, the fractionated data was used in the analysis of information type.

The results presented in Table 4 indicate some cognitive style differences in an individual's information preferences. For instance, on the pre-tests analytics showed a preference for quantitative information while heuristics emphasized qualitative data. Also, the decision styles that emphasized information (H and I) showed a preference for qualitative information. These differences were significant in only one case for the post-tests.

Both experimental contexts asked subjects (again on a pre-post basis) their perceptions regarding the quantity of information they were given. As Birnberg [1975] remarked, information need perception is an important design constraint for accounting information systems. The results indicate that there were some differences in both information need perception and the attitude toward actual information availability among the different cognitive styles. The pre-questions could be interpreted as having measured information need perception, while the post questions tended to concentrate on the degree of satisfaction with actual information available.

These conclusions reinforce the two points discussed in section on Performance Effects. There is cross-contextual agreement which increases the confidence in the statistical results, and low performance diagnosticity which supports our current but limited understanding of cognitive style-based informational differences.

INFORMATION STRUCTURE EFFECTS

The second major area of analysis facilitated by these experiments was the empirical evaluation of alternative information structures. IS4 was primarily designed for a two by two factorial study of the coarseness (aggregation) and completeness (variance feedback) of information. Four different information structures were supplied to subjects on a random basis. The four information structures were: I1 = coarse information without complete feedback I2 = coarse information with complete feedback, I3 = fine information without complete feedback, and I4 = fine information with complete variance feedback. *Fine* information entailed additional detail concerning manufacturing costs whereas *complete* variance feedback added absolute and relative accounting variance measures to the financial statements.

This particular research design was an extension of earlier studies by Mock [1973] and by Mock and Driver [1975] which analyzed the effect of complete variance information on performance. The current two-way design facilitated analysis of more comprehensive variance feedback (I2 and I4), of finer information, and interaction effects.

Although it may be argued that each information set is payoff relevant, the provision of explicit variance information and finer cost information may provide some attention-directing value to the subjects. The additional feedback eliminates some of the subjects' processing needs. Thus, improved performance may be hypothesized for subjects receiving the more complete feedback.

H4: Subjects receiving more complete feedback (I2, I3, and I4) are expected to outperform other subjects.

The results of basic profit performance analysis are presented in Table 5. A two-way analysis of variance revealed significant main (coarseness and completeness) and interaction effects. (When decision time and number of decisions were analyzed, the main effects were not significant).

It may be noted that a one-way analysis of profits in relation to information structure does not result in any significant differences (see Vasarhelyi and Mock [1976]). However, once the factorial analysis is introduced, a clear pattern of interaction and main factor influence can be observed. This pattern indicates the influence of differences in information structures on decision-maker performance. These results are consistent with the earlier ones [Mock (1973)] that attributed superior performance to explicit budget variance information. As seen in Table 5, decision-makers that were supplied with coarse information and complete budget variance information showed the highest profit performance. The finding that the finer feedback

TABLE 5

Effect of Coarseness of Information and Completeness of Feedback on Performance [IS4 Experiment]

	Average Profits Earned ($1,000)	
	Incomplete Variance Feedback n = 54	Complete Variance Feedback n = 66
Coarse Information (n = 56)	$96.10	$124.70
Fine Information (n = 64)	97.10	97.40
	F - Values	Significance Level
Coarseness	7.1	.03
Completeness	4.5	.01
Interaction	3.5	.06

information (details in the various cost components) did *not* have a positive effect on profit performance was a significant result.

The results in this section show much higher performance diagnosticity than the previous ones. This can be explained by a series of factors. First, results are not being examined vis-a-vis cognitive styles, therefore compensatory behavior in omitted variables is not involved; secondly, the IS context is more analytical in nature and has built-in relationships that determine outcome and finally, an improved statistical methodology, using the 2 x 2 design allows for further explanation of the results.

JOINT EFFECTS OF INFORMATION STRUCTURE AND COGNITIVE STYLE

The previous analyses have not considered the interactions that may take place between information and cognitive style. These effects are denoted in the preceding paragraph as compensatory behavior in omitted variables. For example, if the integrative decision style is indeed more complex and has a preference for a greater amount of environmental load (in this case feedback), integratives may be expected to perform best in I4 conditions. Obviously a number of hypotheses could be formulated for each cognitive style and information set (see, for example, Driver and Mock [1975]). As cognitive style effects were not significant, such hypotheses will not be developed.

In Table 6, the average profits and decision times are computed for each cognitive style and information structure. It can again be noted that because of the ex post facto cognitive style classifications, cell frequencies are quite uneven. This of course leads to a number of statistical problems. Nevertheless, a two way analysis of these performance variables, plus number of decisions completed, was conducted. As the results in Table 7 show, only information structure differences were significant.

SIGNIFICANCE OF FACTOR PRICE CUES

Finally, we consider the problem of determining the decision maker's information processing (ϱ) and decision (α) functions within an experimental context. As was discussed earlier (see Table 2), regression analysis was used in IS1 and IS2 to estimate the relationship between factor price cues (i.e., costs of inputs in a manufacturing setting) and actual subject decisions. This analysis is now developed in more detail.

In Figure 1, a subject's chosen action 'a' was specified as depending on a decision function α, an information processing function ϱ and an information system η, or

$$a = \alpha(\varrho(\eta(x))) \quad (1)$$

The action that will be analyzed is the material input decision M_t. In the IS experiments, all subjects received one-period-lagged cues concerning factor input prices for labor cost ($P_{L,t-1}$) and unit materials cost ($P_{M,t-1}$). Thus in this case equation (1) becomes

$$M_t = \alpha(\varrho(P_{M,t-1}, P_{L,t-1})) \quad (2)$$

TABLE 6

Supporting Data for Table 7
Average Profits (P) and Decision Times (T) Classified by Cognitive Style (C/S) and Information Structure (I/S)

Decision Style			Information Structure			
			I_1 P 95.8 T 23.7	I_2 P 111.9 T 18.8	I_3 P 107.3 T 17.9	I_4 P 96.7 T 25.6
D	P(thousands)	111.0	81.8	66.7	140.6	101.1
	T (min)	23.0	15.6	15.1	23.5	30.9
	(N)		9	2	4	10
F	P	98.9	97.5	113.6	78.9	80.2
	T	22.3	28.5	18.9	15.7	24.2
	(N)		6	7	4	6
H	P	113.1	117.8	126.8	143.2	100.9
	T	28.7	38.6	21.8	15.2	24.1
	(N)		6	2	1	7
I	P	101.0	98.7	129.9	79.5	103.8
	T	21.5	17.8	17.7	12.4	25.8
	(N)		9	1	2	13
C	P	104.0	90.4	142.3	—	90.2
	T	23.7	24.6	20.3	—	22.1
	(N)		8	1	0	16
Decision Approach			I_1 P 98.0 T 21.6	I_2 P 130.9 T 18.1	I_3 P 97.1 T 19.1	I_4 P 95.1 T 24.6
A	P	102.4	100.6	139.6	91.2	94.6
	T	21.6	24.5	18.9	17.1	24.0
	(N)		18	6	8	26
H	P	109.7	95.5	125.1	106.4	95.7
	T	21.4	18.3	17.5	22.3	25.3
	(N)		18	9	5	22

NOTATION:

Information Structure	Decision Style	Decision Approach
I_1 = Coarse & Incomplete	D = Decisive	A = Analytic
I_2 = Coarse & Complete	F = Flexible	H = Heuristic
I_3 = Fine & Incomplete	H = Hierarchic	
I_4 = Fine & Complete	I = Integrative	
	C = Complex	

MISCELLANEOUS:

P = Profits
T = Decision Time
N = Cell frequencies

Clearly various decision/information processing models could be formulated and experimental data could then be used to test these models. In

IS1, normative decision theory was used to derive an hypothesized model

$$M_t = .5(P_{L,t-1}, P_{M,t-1})^{.5} \quad (3)$$

This model was consistent with observed results, although a great amount of the explained variance was not accounted for. The normative formulation was based upon the best linear unbiased estimator (information processing function)

$$\varrho^*: P_{Mt} = P_{M,t-1} \quad (4)$$

and

$$P_{L,t} = P_{L,t-1}$$

And an optimal (maximum expected monetary payoff) decision rule

$$\alpha^*: M_t = .5(\varrho^*(P_{L,t-1}/P_{M,t-1}))^{.5} \quad (5)$$

Equation (5), then, is the hypothesized material decision and information processing rule. Based upon this formulation, regression analysis was performed for IS4, with the results as seen in Table 8. The analysis was conducted according to the four information structure treatments (I_1, I_2, I_3, and I_4). For each subject population, regressions were run for both M_t and normalized M_t decisions. The latter analysis was done in an attempt to

TABLE 7

Two-Way Anova of Information Structure and Cognitive Style [IS4] F-Values and Significance Levels

	Average Profits	Number of Decisions	Decision Time
Information Structure	3.3 (.10)	6.9 (.05)	3.1 (.10)
Decision Approach	n.s.	n.s.	n.s.
Interaction	n.s.	n.s.	n.s.
Information Structure	n.s.	7.4 (.05)	3.99 (.05)
Decision Style	n.s.	n.s.	1.57 (.20)
Interaction	n.s.	n.s.	1.95 (.10)

Note: n.s. = not significant.

TABLE 8

Regression Analysis Results for Material Decisions Related to Factor Price Cues (IS4)

Experiment and Subject Population	Dependent Variable (Material Decision)	Independent Variable (Factor Price Cues)	$\hat{\beta}$	t value (significance)	R^2
1. I_1 (n = 39)	M_t	$(P_{Lt-1}/P_{Mt-1})^{.5}$	.63	1.67 (α = 05)	.01
2. "	M_t Normalized	"	1.65	3.33 (α.01)	.05
3. I_2 (n = 17)	M_t	"	.49	1.6 (α = .10)	.03
4. "	M_t Normalized	"	.98	1.94 (α = .05)	.04
5. I_3 (n = 15)	M_t	"	.68	1.49 (α = .10)	.03
6. "	M_t Normalized	"	1.84	3.84 (α = .01)	.17
7. I_4 (n = 48)	M_t	"	.36	n.s.	.01
8. "	M_t Normalized	"	1.28	2.79 (α = .01)	.03

minimize the individual differences in decision strategy which had been shown to be significant in Table 9. The normalized M_t were the actual material decisions divided by the individual's mean M decision. By removing some of the individual's differences, overall subject's reactions to cue changes could be more precisely measured. In fact, in Table 8 all IS4 subpopulations show a significant relationship (at the .05 level or better) between the factor price cues and the normalized material decisions. But again, very little of the variance is explained.

For the regressions using M_t, the theoretical value of $\hat{\beta}$ (.05) is of interest (see equation 5). The empirical results vary from that value, but it is apparent that the theoretical model does perform reasonably well.[3]

These results indicate that a number of variables other than changes in factor price cues are affecting the subjects' decisions. It is probable, for example, that some subjects "anchored" on a reasonable estimate of M^*_t, and then reacted in a heuristic, trial-and-error manner to factor price changes. The results contained in Table 8 support this scenario.

In order to evaluate the impact of individual differences and the decision period (a surrogate for period factor price changes) on a subject's performance, a one way ANOVA was applied to the IS4 material decisions (see Table 9). Consistent with the reported regression results, the period effects

were more significant for the normalized M_t. As anticipated, for each set of subjects the individual differences accounted for a major proportion of the observed variance.

These results also support the importance of investigating individual models of human information processing and decision-making (such as cognitive style) if one is interested in a complete specification of the processes contained in the decision and information processing components of Figure 1. The value of a formal decision theory derivation of the possible information processing and decision functions is also apparent. Without such theoretical guidelines, any analyses of human judgment are exploratory.

TABLE 9

1-Way ANOVA of Material Input Decisions According to Period Effects and Individual Difference Effects (IS4)

Experiment and Subject Population	Variable Analyzed Classification (Treatment)	M_t Decision Period	M_t Individual Differences	M_t Normalized Decision Period
I1 (n = 39)	F	.91	2.9	2.95
	d.f.	4,38	38,156	4,38
	significance	n.s.	.01	n.s.
I2 (n = 17)	F	2.13	3.39	4.04
	d.f.	4,80	16,68	4,80
	significance	.10	.01	.01
I3 (n = 15)	F	.78	12.9	6.31
	d.f.	4,70	14,60	4,70
	significance	n.s.	.01	.01
I4 (n = 48)	F	.53	2.05	2.18
	d.f.	4,235	47,192	4,235
	significance	n.s.	.01	.10

SUMMARY

In summary, this paper has presented material in three areas of interest to researchers concerned with accounting systems vis-a-vis (1) behavioral variables, (2) human information processing rules, and (3) decision rules. The paper began with a review of the literature and a brief introduction to a model (Figure 1) that contained the variables of interest. This model can be viewed as continuing the normative perspective of information economics and the more exploratory efforts of describing important behavioral and HIP processes.

The second major segment of this paper considered the information processing evidence contained in four previous experimental studies. Next, some new experimental results derived from two decision contexts were presented. The last section of this paper examined behavioral and informational variables in two experimental settings. In terms of information-use perceptions, the results indicated consistent information structure effects with less consistent cognitive style effects.

The new results can be classified within four areas, two of which were seen to hold for both experimental contexts. In each experiment, cognitive style differences did not explain a significant amount of variation in performance but did result in significant differences in perceptions concerning the type and amount of information. In the IS experiment, information structure effects were seen to explain performance differences, but only a weak relationship was established between factor price cues and factor input decisions.

The latter result indicates that future research will have to utilize and test more complex models of individual differences (such as cognitive styles) and of human information processing. The experimental separation of both information processing and decision functions should be attempted. The ultimate goal of such research is to provide an improved model of decision-making, and thus an increased capability for accounting system design.

On a methodological level, cross-contextual analysis served to increase the confidence on results with low statistical significance. Improved laboratory and statistical techniques may be used to improve this process. Cross-contextual findings discrepancies may serve to indicate context-dependent methods and/or hypotheses.

In addition, the results indicate that the existence of low outcome diagnosticity simply points out the need for the examination of additional component variables and does not necessarily invalidate the underlying theory. Finally, many of these additional component variables should be studied to provide a fair assessment of decision quality instead of the rather simplistic examination of a single outcome (performance) in multi-attribute decision settings.

NOTES

[1]See Mock, Estrin, and Vasarhelyi [1972].

[2]See Driver and Mock [1975].

[3]One reason why the regression model does not perform as well in IS4 as in IS1 may be the fewer (5 versus 12) number of decision periods.

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