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Information Processing in a Simulated Stock Market Environment

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ABSTRACT

This paper describes three studies aimed toward the understanding of human information processing within a simulated stock market environment. Initially, a series of studies in Human Information Processing (HIP) in accounting are summarized, key stating the various approaches, key concepts, and variables. In addition a symbolic model with which to analyze HIP processes in an experimental setting is proposed. Secondly, the stock market simulation is described, with emphasis on its main methodological advantages and shortcomings. The third section presents details of three implementations of the simulation, summarizing the main similarities and differences. The fourth part analyzes, in a comparative framework, the experimental results obtained for the three experiments performed. The last part of the paper discusses the implications and potential generalizability of these results and outlines paths for future research.

The tentative results favor the utilization of a cross-experimental methodology as conclusions are similar for the three stock market simulations. Effects are found concernng subject motivation toward financial rewards and subject attitude changes during the experiment, while little, if any, effects of cognitive style on the decision process are observed. A series of regression modeling attempts are described with mixed results.

ACCOUNTING INFORMATION PROCESSING IN A SIMULATED STOCK MARKET ENVIRONMENT

The study of Human Information Processing in Accounting has added a new dimension to enhance the understanding of accounting phenomena. In summarizing the development of HIP, several authors, Libby and Lewis (1981), Driscoll and Mock (1976), Libby (1981), and the American Accounting Association (1977), surveyed studies in accounting psychology, attempting to organize relevant studies and place them in a context identifying the state of the art.

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Libby and Lewis (1977) proposed a simple information processing model composed of three basic components: input, process, and output. This paper describes a set of three experiments which utilize a stock market setting for the examination of these components. The "input" component is the commonly available stock market information; the "process" is simulated by surrogate decision makers; and the "output" is represented by the subjects' stock trading decisions and their trading performance.

Slovic (1972) stressed the desirability of the utilization of a stock market setting for Human Information Processing studies:

> "...In no other realm are such vast quantities of information from such diverse sources brought to bear on so many important decisions. Careful accumulation and skilled interpretation of this information is said to be the sine qua non of the accurate evaluation of securities."

Slovic (1969), Slovic, Fleissner, and Bauman (1972), and Savich (1977) conducted experiments on human judgment and information utilizations within a stock market evaluation and decision setting. All these experiments utilized hypothetical companies using real (stockbroker) or simulated (student) subjects, with the stock decision as the decision process under study. The studies presented here were effected over a longer range of time (one academic semester) than these others and utilized actual stock prices on the day of trading. The design of these studies allows the examination of several information processing issues along multiple dimensions and across three experiments with increased realism at the expense of some experimental control.

Libby and Lewis (1977) pointed out three basic research approaches in Human Information Processing: (1) lens model, (2) probabilistic judgment, and (3) cognitive style. On the other hand, Driscoll and Mock (1976) arranged human information processing into a hierarchy which divides HIP models into the normative and the descriptive. These two taxonomies are somewhat analogous in that emphasis is placed on the technique of the analysis and/or model presented as opposed to the key variables considered. Such a "technique" emphasis is discussed by Slovic and Lichtenstein (1971) while comparing the Bayesian and regression approaches to human judgment analysis:

> "...some new approaches might be even more illuminating. ...subjects are processing information in ways fundamentally different from Bayesian and regression models. Thus, if we are to pursue this line of research we will have to develop new models and different methods of experimentation."

This paper attempts to develop such new approaches by extending the stock market analysis setting to a hybrid model and exploring human information processing issues under a multitude of techniques. Mock and Vasarhelyi (1977) have proposed a framework which synthesizes the lens and information economics models, and their model will be adapted to analyze human information processing within a stock market framework. This model should not be considered preferable to other proposed models, but rather as a useful framework in which to examine phenomena of interest.

SOME HUMAN INFORMATION PROCESSING MODELS

Figure 1 presents the basic elements of a Human Information Processing system within a decision framework. These main elements are: the environment, information, and the man-decision context. This

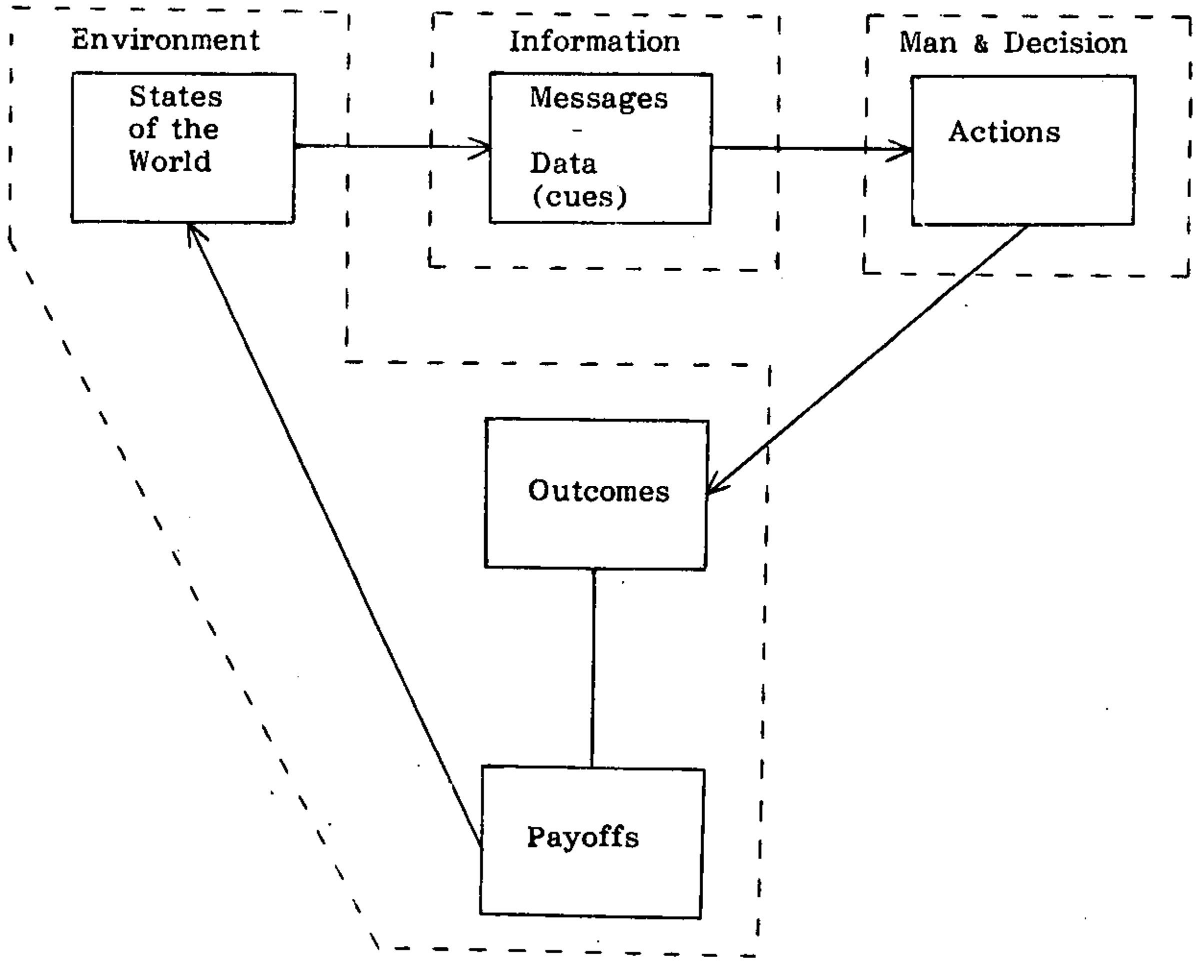

Figure 1. An Elementary HIP Model*

*Adapted from Mock (1971) and Driver and Mock (1975).

model can be compared with Libby and Lewis' (1977) three-component system by aggregating the environment and its measures into what could be called an "input" factor. The man and his decision context are the "process," and the outcomes and payoffs are the "output" element.

This very elementary model is also often discussed in a different format and approach and has been called the "lens model" (Brunswich, 1955; Ashton, 1974; Libby, 1975). The focus of the lens model is on the message (cues) which link, as a measurement process, the environment to the individual judgment or prediction process. Figure 2 displays an adaptation of the lens model highlighting the three main elements which are common both to the lens model and to the elementary HIP model.

While the HIP model is information-economic in nature in that it evaluates the decision setting in macroeconomic terms, the lens mode, because it is derived from psychology, emphasizes behavioral variables. Experiments that are performed under the HIP approach are more business-oriented but have been somewhat unsuccessful in attempting to explain basic accounting decision making issues (Mock, 1971). On the other hand, lens type experi-

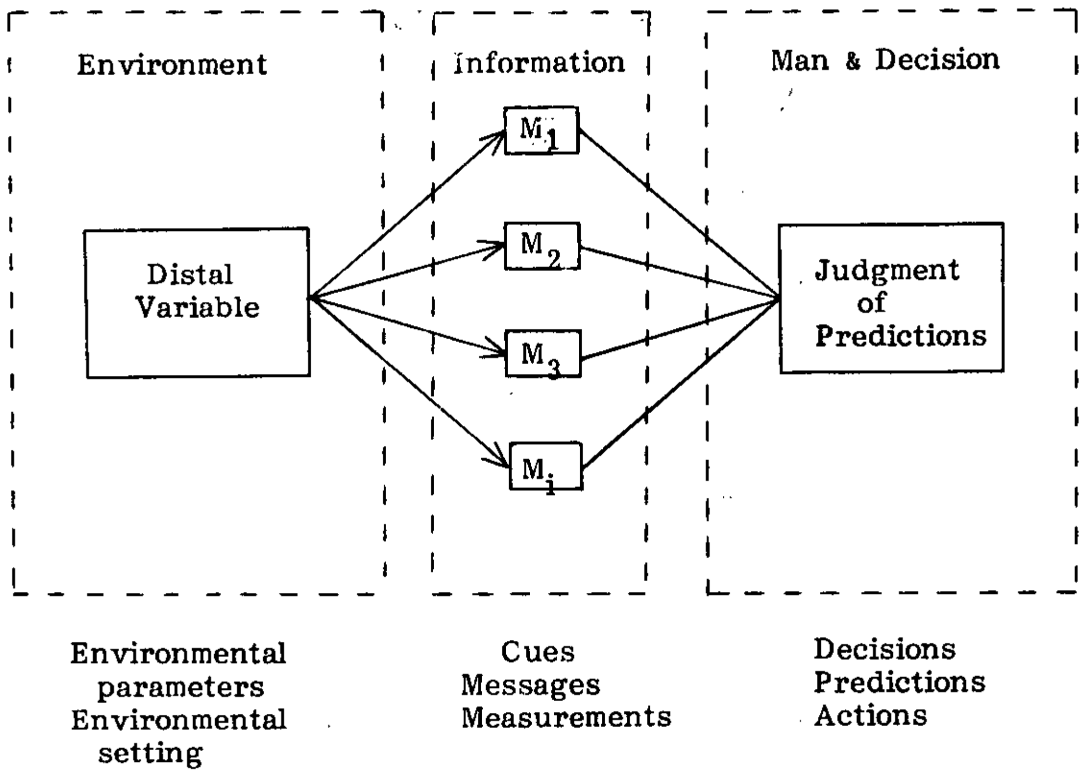

Figure 2. The Brunswik Lens Model*

*Adapted from Ashton (1974).

ments have been conducted emphasizing behavioral contexts and data interactions within the framework of the lens model's three key parameters: cue validity, cue utilization, and the response validity of decision makers (Ashton, 1974).

A large number of independent or interdependent information variables have been studied in the literature (see Birnberg, 1975; Libby and Lewis, 1977; Vasarhelyi and Mock, 1977; and AAA, 1977, for studies which have listed some of these variables of HIP interest). Most of the empirical studies, however, have concentrated on controlled experiments dealing with very few variables. These studies, many of which in essence replicated psychological studies while employing a more business-related context, have added validity and created a basis for more complex models with interlinked variables.

The normative versus the descriptive dichotomy of HIP models deserves further attention. The normative approach will apply a statistical technique (e.g., Bayes' theorem), linear programming, or regression analysis and set the optimal decision path, so that normative studies may examine how closely human decision makers follow such models. In contrast, the descriptive approach emphasizes the duplication or explanation of how decisions are made, without concern for their optimality.

Slovic and Lichtenstein (1971) compared two of the basic schools of thought in normative models emphasizing: (1) models, (2) major experimental paradigms, (3) key independent variables, and (4) major empirical results and conclusions. Their recommendations, as quoted earlier, advocate new approaches. One manner in which this recommendation can be given effect is in the development of descriptive models of a very pragmatic nature. One such model will be proposed later in this paper. Figure 3 presents an all inclusive framework aggregating the earlier two figures.

The states of the world are not necessarily discrete in nature. They include a number of variables that relate the relevant environment to the decision under consideration. This environment is measured through accounting processes which code levels of activity of the basic variables into messages (cues).

The effect of messages has often been studied in terms of the value and content of information, concepts which must be very narrowly defined for any useful application. This paper expands on these parameters by studying attributes of information such as the frequency of information utilization, form of presentation, type, and quantity. Information supplied along these four basic dimensions is absorbed (received) by the human information processor through a process of filtering. Many studies have examined a particular aspect of this process called "information overload" (Chervany and Dickson, 1974; Casey, 1981). Other aspects of this filtering process include attention to information, systematic bias, and perceptual deficiencies. These filtered messages are then associated and related to the individual's background factors such as education, work experience, and sex. The method and structure of the combination and processing of the received messages (after filtering information) are defined as the individual's cognitive style. If a certain level of consistency is found in a cross-individual comparison of these methods, a taxonomy of cognitive styles might be said to exist.

One taxonomy of cognitive style might be based on method of decision as in the "Analytic vs. Heuristic" framework (Huysmans, 1970; Peters, et al., 1974; Mock, et al., 1972), which is based on the Jungian approach. Another taxonomy possible is that proposed by Driver (Driver and Mock, 1975; Mock and Vasarhelyi, 1976)

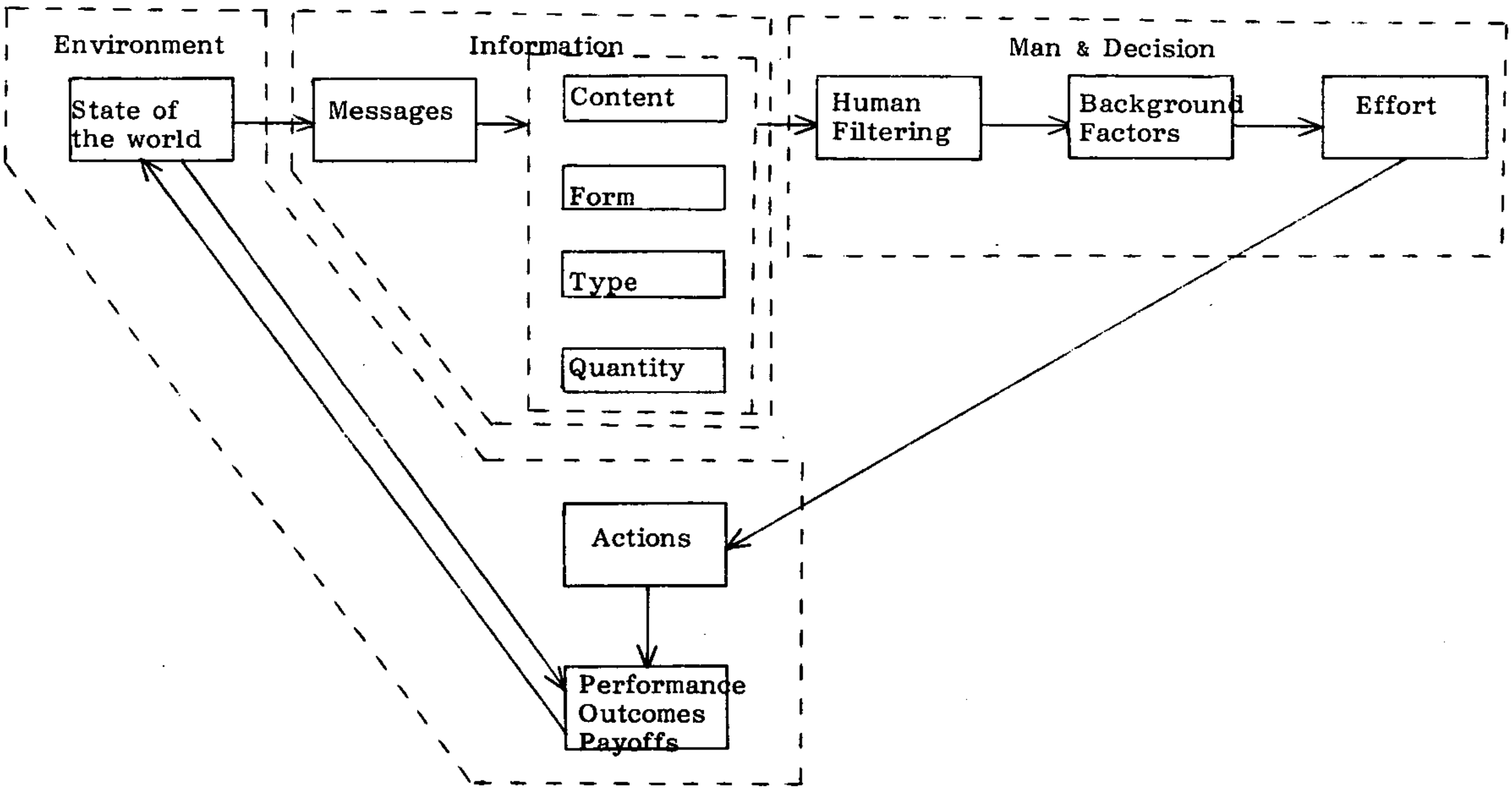

Figure 3. Human Information Processing and Decision Model (HIPDM)

which emphasizes information utilization and focus multiplicity.

The nature and effects of the feedback process are considered in this paper in terms of changes in attitude and perception by decision makers. With this in mind, the next section introduces the stock market simulation with special emphasis on its key methodological and experimental features.

STOCK MARKET SIMULATION

A stock market situation presents a rich potential for research in decision making, for its deals with issues familiar to the businessman or business student, it has a clear decision outcome, and it involves a wide range of choice. On the other hand, a series of problems including data privacy, meaning of subject performance in a stock market situation, and difficulty in the acquisition of real traders as experimental subjects raises difficulties for its utilization.

Methodology

The main methodological objective of this research is the extension of HIP studies into a multivariate, multitechnique descriptive study of a decision process. The multivariate approach allows for the simultaneous examination of the interaction of diverse variables, while the multitechnique approach helps in the avoidance of the biases inherent in the adoption of a single model. Slovic and Lichtenstein (1971) discusses this issue:

> "Can...differences in the focus be attributed to the influence of the model used? Is a researcher inevitably steered in a particular direction by his chosen model? To a certain extent this is certainly true...In general, however, we believe that the major differences in research emphasis cannot be traced to differences between the models. On one hand we see neglected problems for which a model is well suited...on the other hand, we see persistent, even stubborn, pursuit of topics for which the model is awkward."

To this they add a discussion of the methodological implications of the use of singular or multiple paradigms:

> "Of several hundred studies, only a handful indicate any awareness of the existence of comparable research under another paradigm...Singleminded dedication to one paradigm is disturbing since it sugests a lack of concern with basic, substantive issues."

The usage of multiple paradigms requires a flexible and configural initial model as defined earlier in Figure 3, and such a technique must be used as a basic approach and adapted to the specific experimental situation.

The adoption of an experimental setting is a basic methodological choice for the conduct of any research. Here, the choice follows earlier research effort and, as most laboratory simulations, it benefits from additional experimental control of the decision setting, but suffers in terms of generalizability.

Essential to the Human Information Processing and Decision (HIPD) model are its three main components: man, information, and the environment. These are part of all types of decision processes and could also be studied in real settings. The decision to adopt the laboratory methodology requires either the simulation or the surrogation of each main component.

The decision maker, supposedly a manager using accounting information for decision making, will be surrogated by the use of graduate students. The discussion of such a practice is extensive in the literature (Cunningham, et al., 1974; Abdel-Khalik, 1974) indicating that students do not behave as businessmen. Such an objection is not important in this research in that replication of actual businessmen's decisions is not being attempted. Rather, the main interest lies in the constructs of decision making and the individual differences between people and their usage of information.

The information being supplied and used throughout the experiments is highly monitored and when desired can be controlled partially for experimental purposes. Subjects may or may not be directed to particular sources of information, limited by the rules of the game from other information, or penalized for certain activities. The tighter the controls, however, would lead to loss of generalizability in terms of realism of the task. The tradeoffs of task specificity and control are extensively discussed in the experimental methodology literature (Kelinger, 1973). Measurement is performed through subject monitoring, surveys of subject perceptions, and system traces.

The environment and decision context are the key issues in the success of the simulation. Problems with the implementation of a realistic stock market simulation led to the utilization of successive experiments and the subsequent comparison of results. This approach facilitates the generalizability of finding and provides a limited validation of the simulation results.

While a pure simulation of the stock market could lead to very unrealistic and theoretical situations, the usage of a real stock market setting and the monitoring of real-life trading would be an acceptable survey methodology. However, such an approach, no matter how interesting, would not meet the research objective, in that the control of subject acquisition, usage, and need for information would be virtually impossible.

These conclusions led to the development of a hybrid simulation in which traders would have limited amounts of resources to use and would execute simulated trades in the day-to-day stock market world. This type of exercise is not unusual in finance and investment type classes at business schools, but its utilization in information systems research (as in the present context) is relatively original.

Because simulated trading may decrease subject motivation (in real life real financial incentives exist), a scheme for rewarding participants was developed. The effect of financial rewards was one of the initial experimental questions to be tested.

The initial SX1 experiment emphasized methodological issues in the usage of a stock market simulation. The following (SX2, SX3) experiments refined the experimental design and led to the testing of several additional questions.

Experimental Procedure

The general framework for inquiry has been established in the earlier sections of this paper. However, additional details of the design process must be summarized: first, measurements of the frequency, type, and quantity of information used and traces of the decision methods had to be developed; second, measurements of subject cognitive style had to be derived. This led to the choice of the two cognitive style taxonomies already introduced. Mock, et al., (1972) present an extensive discussion of the characteristics of the A/H framework, a framework used by Vasarhelyi (1977) to examine type and quantity of information used in decision making. The

A/H test used in this research was developed and validated by Vasarhelyi (1973). The classification of subjects within the Driver framework was performed by administering the Administrative Problem Solving Exercise (APSE), (Driver and Mock, 1975).

The pre-experiment and post-experiment questionnaires were designed to measure, by subject self-appraisal, items related to information utilization. Biographical data was also collected through these questionnaires.

The experimental design also required some definitions of a more technical nature on additional details of the simulation. Among these were length of the experimental periods, type of subject monitoring, stock availability, reporting, and technical systems definitions.

The length of the experiment was determined by the sixteen weeks of the academic semester. This time span probably caused subjects to try short term trading strategies, but on the whole it was felt that they would act as if they were trading to maximize long term gains.

The large number of variables to be tested and their nature suggested the need for validation measures. Whenever possible, two different measures of the same variable were taken in SX1. Later many of these were deleted in SX2 andd SX3.

For the implementation of the SX1 experiment, a subset of the New York Stock Exchange stocks was used. The selection procedure and its rationale can be found in Ewing-Chow (1977). Subjects were asked to keep their own records of portfolio status. These selection and reporting procedures were changed for later versions of the experiment.

Trading prices were based on the previous day's closing prices. SX1 required students to trade without knowing exact trading price, while SX2 and SX3 had students enter their trading price as of the previous day's closing. The prices were then audited by the system. A trading form was used for entering transactions and this form also served to gather "protocol" type information (see Clarkson, 1962 for a similar type of methodology) for structural types of analysis related to the decision process. A trace for all trading activity was generated through the Portfolio Management System (PMS) for later analysis.

Most of the subjects were first-year MBA students, about half of them coming from the part-time night program with more extensive working experience. Participation in the SX simulation was an integral part of the accounting courses and the students were informed at the beginning of the semester that 10% of their course grade would be determined on the basis of their "SX efffort," but would not be conditional on any specific variable such as frequency of trading, type of stock bought, etc. It also made clear that keeping cash would be an acceptable strategy.

Students were asked whether they would invest their own funds in the simulation. Only students investing their own money (up to $20.00) participated in the financial rewards. For every real dollar invested, subjects would receive 10,000 SX dollars for trading. Non-investors of real money were allocated 100,000 SX dollars. Additional questionnaires were distributed during the semester, monitoring the subjects' perception of their investment effort.

This experimental design permitted the measurement of background factors of decision makers through the bio data form, the measurement of attitudes and attitude changes in relation to information utilization, and decision strategy through the pre and post questionnaires, and additional measures through PMS traces. Also, trading forms were used as "protocols" for the examination of the trading process.

IMPLEMENTATION OF THE SIMULATION

An initial pilot experiment was conducted for several weeks after which the first version of the experiment (SX1) was implemented. Table 1 compares the three SX versions and their key features.

The analysis of subject feedback, performance, and questionnaire data led to streamlining the subsequent experiments. Among these changes were the following: the elimination of duplicate (methodological validity checking) questions; replacement of the fractionalization scales in the valuation of trading strategies and information utilization by Likert type scales; and the addition of features that allowed subjects to enter their own transactions into the system, query for portfolio status, trade on margin (paying for the borrowed funds the call rate of money plus 1.5%) and to sell stocks short. The usual SEC and NYSE restrictions applied to those types of operations.

The next section stated the key problems in the form of hypotheses, related these to the literature, discussed the results, attempted to evaluate the value of the SX setting as a research tool, and charted the adequacy of the evolution from SX1 to SX3.

EXPERIMENTAL RESULTS

Experimental questions and results will be divided into four main areas:

- Basic research questions
- Feedback and attitude change
- Modeling of the decision process
- Cognitive style effects

These four areas will allow the utilization of diverse HIP paradigms in its analyses. Data gathered throughout the experiment will determine in an ex post facto manner the cognitive style of the subjects. This analysis emphasizes perception data as opposed to directly measured data. The present analysis could have focused on decision protocols and system traces, but these were not used as such analysis would detract from the main focus of this paper. The key objective is a multitechnique and multiexperimental analysis of data and the modeling of decision processes based on perceptual data.

Basic Research Questions

H1: Investment of real money in the experiments and financial rewards will lead to improved s-ubjects' performances.

H2: Investment of real money in the experiments will increase subject's trading activity.

Financial rewards were introduced to increase subject motivation and attention to the simulation. Despite the fact that clear measures of performance are available, the literature does not clearly support correlations between subject motivation and performance due to efficient market considerations. Also, with some reservations, frequency of trading might be used to measure effort and motivation in the experiment.

Subject performance was measured by comparing beginning and ending portfolio positions which were affected by dividends received, change in the market value of the stocks, cost of margin money, and interest earned on cash balance.

The results of a t-test between the real money investors and the non-money investors are shown in Table 2.

Table 1. The SX Experiments

	SX1	SX2	SX3
Subjects (MBA students)	97	51	56
Average work experience	3.5 yrs	4.7 yrs.	5.6 yrs.
Date	Spring 75	Fall 75	Spring 76
Transactions allowed	Buy, sell	Buy, sell, sell short	Buy, sell, sell short
Margin allowed?	No	Yes	Yes
Security choice	50 stocks	Any listed stock	Any listed stock
Availability of reports	Every two weeks	Any time upon terminal query	Any time upon terminal query
Mode of trans-action	Form	Form and enter through terminal	Form and enter through terminal
Instruments administered	Bio Pre Post	Bio Pre Med Post	Bio Pre Post
Reward sustem	Proportional to investment	Proportional to investment	Prizes for winners
Programming language	APL	BASIC	BASIC
Class type (graduate level)	Intro Accounting	Intro Accounting	Intro Accounting Advanced Accounting

Table 2. One-tailed T-Tests by Investment
Investment of Real Money*

VARIABLE	SX1	SX2	SX3
R.O.I.	t = .66 n.s. **	t = 1.96 $\alpha \leq .05$	at = 1.31 $\alpha \leq .10$
Number of Daily Transactions	t = 3.74 $\alpha \leq .01$	t = 1.25 n.s.	t = 1.71 $\alpha \leq .05$
Number of Transactions	t = 2.29 $\alpha \leq .025$	t = .43 n.s.	t = 1.35 $\alpha \leq .10$

* Group 1--invested real money and participated in financial rewards.
Group 2--invested only ficticious money: no financial rewards.

** Not significant.

The results partially support stated Hypothesis I. No effect is found in SX1 while some significant effects can be observed in SX2 and SX3.

The results displayed in Table 2 showed reasonable consistency. The number of daily transactions measures how many daily transaction forms were submitted regardless of how many buy and sell orders each contained. The total number of transactions reflects the number of buys and sells during the experiments.

Results tested through a one-tailed t-test support H2, indicating that subjects who invested their own money were more active in trading. The daily trading frequency will be later used in this paper as a surrogate measure of subject effort in the experiment.

Feedback and Attitude Changes

H3: The experiment will considerably change subject perception of information need, data to be used, and decision strategy employed over the course of the experiment.

This hypothesis, stated in a general form, will be tested for several variables through the comparison of pre and post questionnaires. The hypothesis is based on a series of previous findings (Vasarhelyi, 1977; Mock, et al., 1972) and is considered in relation to information overload factors (Chervany and Dickson, 1974).

Questionnaires dealt with three basic areas: type of data to be used, specific source of information used, and decision strategy. Pre-questionnaires reflected subject attitudes and expectations prior to the experiment while post-questionnaires reflected subject perception and measurement of phenomenon intensity. A paired comparison of pre and post responses on a subject basis achieves the elimination of subject measurement biases. The results are displayed in Table 3 and show some disagreement, but parallel effects, among the different versions of SX experiments.

To summarize subject reaction, half of the questionnaire items show significant changes in subject attitudes, estimation, and perception from the beginning to the end of the experiment. The weakest effects can be observed in general data type, while the strongest are found in the examination of subject approach (not measured in the SX3 experiment).

Subjects perceived themselves as relying more on qualitative data (tips and feelings) than they initially estimated. Also, their early suspicion of intensive usage of quantitative data was continued. These conclusions together show parallel validity among the experiments and display a strong tendency toward subject attitude change throughout the experiments. Subject perception of learning was measured objectively only in SX3, but open-ended course evaluations in all experiments tended to disclose strong technical learning on such related matters as the stock market and accounting statement analysis.

In the aggregate, the findings seem to support H3 and do not show sizeable differences among the experiments in terms of noise or validity.

Cognitive Style Effects

H4: Decision style and decision approach are interrelated measures of cognitive style.

The third approach discussed in Libby and Lewis (1977) involves the study of cognitive style in human information processing. Two basic taxonomies have been used in parts of this experimental study. The first, which classifies subjects into five categories, is called decision style (Driver and Mock, 1975), while the second decision approach uses the Analytic x Heuristic dichotomy (Huysmans, 1970; Vasarhelyi, 1977). Hypothesis 4 is based on findings by Mock and Vasarhelyi (1976) which indicate that the two cognitive style taxonomies are interrelated. Table 4 cross-tabulates the subject occurrences in the three experiments in relation to decision approach and decision style. The result of a chi-square test (Chi-square = 4.43) fails to reject the null hypothesis ascribing independence to the classifications, thus failing to support the stated hypothesis. These results, based on the 166 subjects of the three experiments are in disagreement with the ones presented by Mock and Vasarhelyi (1976) where the independence of scales hypothesis is rejected at a significant level.

H5: Subjects will perform equally, regardless of their cognitive style.

H6: Trading frequency will vary along the cognitive style dimension.

Individuals and their personalities vary along a wide range and along many dimensions. Past studies (Vasarhelyi, 1977)

Table 3. Pre-Post Attitude Changes
Resuls of Paired T-Tests

#	Description	SK1		SK2		SK3	
	a. Type of Data	t	sig	t	sig	t	sig
1	need for Quantitative data	.25		1.27		1.12	
2	need for Qualitative data	-1.92	.1	- .52		1.19	
3	need for Economy-wide data	.81		2.55	.01	.92	
4	need for Specific security data	-2.19	.05	- .42		-1.65	.1
	b. Source of Data						
5	importance of friends' tips	1.92	.1	.63		1.35	
6	past financial statements	- .22		1.83	.1	3.11	.01
7	personal feelings	-1.89	.1	-1.20		.72	
8	stock broker influence	- .19		1.66	.1	1.89	.1
	c. Decision Strategies						
9	careful analysis	-1.01		1.80			
10	random selection	-2.10	.05	-2.06	.05		
11	intuition	- .13		1.72	.1		
12	systematic elimination	.53		2.84	.01		
13	familiarity with stock market					2.73	.01
	Sample Size	89		40		39	

Table 4. Cross Tabulation of Decision Approach Versus Decision Style

	Analytic	Heuristic	
Hierarchic	8	15	23
Integrative	19	15	34
Flexible	22	19	41
Decisive	18	28	46
Complex	13	9	22
TOTAL	80	86	166

seem to indicate that performance is not usually a function of cognitive style and that subjects will compensate for their deficiencies by utilizing their strengths to a greater extent.

In consequence, H5 hypothesizes no differences in performance based on cognitive style, but according to H6, differences can be expected among the several components of the decision process. For example, using the HIPDM as a discussion model, it would be expected that subjects would substitute between their usage of quantitative and qualitative information according to their cognitive style. Hypothesis 6 states that these differences will be reflected along the "number of transactions" dimension as a surrogate measure for "effort."

The results in Table 5 support H5 and reject H6. The effects, if any, are consistently weak. The support found for Hypothesis 5 might simply imply that no effects were found within the described context and that more testing of variables might be necessary to fully examine the effect of cognitive style on performance. Such testing could be performed along the same line as this hypothesis or along a model construction methodology as discussed below.

Decision Modeling

H7: Information utilization perception and background variables will significantly explain stock market trading performance.

H8: Differences will be found in the weighting of information utilization parameters between heuristic and analytic decision makers.

H9: Logical structuring of information and background variables will improve performance explanation.

Table 5. Profits and Transaction Frequency in Relation to Cognitive Style (t-test, F test)

	SK1	SK2	SK3
	Heuristic x Analytic Taxonomy (t-test)		
Profit (ROI)	t = .53 α = n.s.	t = .75 α = n.s.	t = 0.94 α = n.s.
Daily Transactions	1.23 n.s.	1.40 n.s.	.27 n.s.
Total Transactions	.31 n.s.	1.40 s.s.	.34 s.s
Sample Size	88	40	50
	Driver Taxonomy (F Test)		
Profit (ROI)	F = 1.1 α = n.s.	F = .98 α = n.s.	F = .18 α = n.s.
Daily Transactions	.21 n.s.	1.96 n.s.	.99 n.s.
Total Transactions	1.1 n.s.	2.26 $\alpha \leq .10$	.50 n.s.
Sample Size	78	37	39

*n.s.--non-significant

Regression will be utilized, in an exploratory mode, to test these hypotheses. A similar methodology can be found in Hughes and Downes (1976). Hypothesis H7 to H9 were formulated mainly with the intent of focusing on the regression modeling approach and not for strict statistical analysis.

The first question which must be addressed is whether to employ pre or post questionnaire data for analysis. The literature (Slovic, 1971) seems to imply that subjects have little insight into the nature of their own decision process, but common sense would dictate that, after the experiment, subjects would have a better feeling for the key factors in their experiment-related decision making. For exploratory purposes, regression analysis was performed dividing the group into analytics and heuristics and also using the entire population. All three simulation versions were analyzed and both pre and post data were included. ROI was information utilization used as the dependent variable, with several others, including information utilization perceptions, information type perceptions, background factors, and frequencies of trading used as independent variables. The results are shown in Table 6, which separately presents pre and post regression analysis results.

Table 6 displays adjusted R squares, which express the "explained" percentage of the total variance of the dependent variable, adjusted for sample size. The results indicate that post questionnaires are better in terms of variance explanation. Overall, these results are weak, and hardly support stated Hypothesis 7. An explanation factor of about 40% is not necessarily a bad result, in that theory-based expectations took into account efficient market considerations and forecasted that personality and background factors would explain only a small part of the variance of the dependent variable. Unfortunately, this explanation factor is not consistent among all the experiments and therefore cannot be considered as supporting the hypothesis.

H8 states that there will be significantlly different equations explaining analytics and heuristics. Such a hypothesis can be tested by a test for equality between coefficients in the two equations (Johnston, 1963) which compares the sum of squares of the residuals for each population and for the joint population adjusted for their degrees of freedom. This ratio is an F coefficient which tests hypothesis of identical coefficients. In this case, the test led to two values of F significant at the 1% level (in SX1, F=5.6 and in SX3, F=2.98) and one value not significant at the 10% level (SX2, F=.16). These results are based on the assumption of normality of residuals and tested for multicolinearity through a Durbin-Watson test. The smallness of the samples and the divergence in results does not warrant unqualified hypothesis support.

After the initial set of regression runs, seven variables of the post questionnaire were chosen for additional testing. The criteria for inclusion were the frequency and ranking of the independent variable in the explanation of the dependent variable in the larger runs. This reduced the initial set of twelve dependent variables to seven. These variables were:

Pos001 Perception of usage of quantitative information

Pos006 Perception of usage of past financial data

Pos015 Perception of sufficiency of data

Pos002 Perception of usage of qualitative data

Pos012 Perception of "feelings" as a decision strategy

Table 6. Variance Explanation Across the SX Experiments Adjusted R Squares)

	Sx1		Sx2		Sx3	
	Pre	Post	Pre	Post	Pre	Post
All Ss.	7%	16%	40%*	44%*	16%	21%
Analytics	20%	58%*	n.a.	n.a.	49%*	47%*
Heuristics	45%*	50%*	20%	17%	46%*	53%*

n.a. -- Data not available due to sample size limitations.

* Significant at the 5% bad.

Bigtr Number of days on which transactions made

Age of the subject

These variables are listed in increasing order of dependent variable explanation after performing an ordinal ranking procedure for a decision of independent variable inclusion. It is interesting that the first five variables are informational in nature while the sixth is a background variable, and the seventh is our surrogate effort variable. This effect is not purely accidental nor does it necessarily support the HIPD model as the initial set of regression variables was selected based on HIPD considerations.

A second set of regressions was developed considering these variables both in a regular regression procedure and in a hierarchical inclusion procedure. This hierarchical method was based on the structure of the HIPD model. The hypothesis advances the view that the second mode of analysis will present a considerably better explanation of the dependent variable than the first. Table 7 displays a summary of the results of this effort, results which present a disappointing level of explanation of the dependent variable. The low values of the adjusted R squares do not allow for even tentative conclusions about preferability of the models.

On the whole, the results presented are quite interesting. The three first areas show some hypothesis support, while the last area introduces a methodology of analysis in an exploratory model and uses hypothesis simply to add focus to the

Table 7. Stepwise and Hierarchical Regressions on Selected Variables

Dependent Variable - ROI

Independent Variables		Use of Historical Information	Information Sufficiency	Qualitative Information	Quantitative Information	Feelings	Age	Trans-actions	R^2
SX1	H (n.s.)		0						
	S (.10)	X	XX		XX		X		.10
SX2	H (n.s.)	0							
	S (.10)	XX				X	X		.17
SX3	H (.10)	X	X	XX	X	X		XX	.24
	S (.10)	X		XX	X	X	X	XX	.26

H--hierarchical inclusion
S--stepwise inclusion

n.s.--Not significant

** Variables checked with an XX were included at a significant level in the equation, and the equation is overall significant.

Variables with an X are part of an overall significant equation.

Variables with an o are individually significant, whereas the equation as a whole is not.

analysis. Large sample sizes and tighter measures are considered necessary for a more conclusive application of this methodology.

CONCLUSIONS

This paper has described a set of three experiments and presented the Human Information Processing and Decision model for the analysis of a series of phenomena. This model, a combination of the Information economics and the lens model, has served basically to present a framework for this analysis. A more comprehensive and more fully discussed development of models of this type can be found in Mock and Vasarhelyi (1978). The main methodological objective of this paper has been to apply a multitechnique analysis to a HIP problem. Three SX experiments of slightly different characteristics were used for this purpose, with four key areas of analysis considered. The first area emphasized a few questions concerning the experiment itself. The conclusions support the assertion that financial motivation, even if small in amount, will lead to increased commitment and effort on the part of the subjects. On the other hand, this increased commitment did not lead to improved subject performance.

Second, an analysis of attitude change on the part of individuals in relation to data utilization, frequency, and strategy in trading was performed. The results indicate considerable change in perception between the beginning and the end of the experiment. The results of these first two areas present excellent cross-experimental validity, leading to stronger reliability of results despite the low significance level of the individual results.

The third area of analysis emphasized cognitive style. The results obtained display very little, if any, of cognitive style effect based on either a decision style or decision approach taxonomy. These results, when compared with the ones presented by Mock and Vasarhelyi (1976), lead to the conclusion that more objective measures and tighter controls are needed in the measurement of information utilization type and frequency. These results are in agreement with Slovic's (1971) conclusions that decision makers in general have little insight into the nature and process of their own decision making. Also, these results imply that tighter and more consistent measures and taxonomies of cognitive style are needed with special emphasis on accounting decision making and information utilization.

The fourth area of modeling the decision process presents some puzzling results. Regression attempts, such as the ones presented here, failed to provide any significant explanation of variances. More selective regression attempts, according to the HIPDM model, included a simultaneous or hierarchical procedure, and using performance (ROI) as a dependent variable and several others (see Table 7) as independent, led to low but significant explanations, particularly broken down by the different decision approaches. The small sample size limits a thorough testing of the statistical significance of these differences as the number of cases does not lead to stable regression coefficients.

The overall conclusion led to the belief that cross-experimental comparisons support inter-experimental consistency and potentially the perception of a slight methodological improvement, despite an increased complexity of the game. This comparison of experimental versions adds credibility to the results, but also clearly points out the need for significant changes in the setting and experimental measurements in order to reach improved results.

The longer time period, the utilization of real-stock prices in a more realistic stock market presented considerable benefits in terms of external validity. On the other hand, it also added noise and difficulties in experimental monitoring for the researcher.

The next step in this effort will be the analysis of subject trading protocol and the tightening of the research design, possibly by extending the time frame of the experiments to an academic year and by closer monitoring of subjects' information exposure by means of protocols, periodic questionnaires, and short "knowledge quizzes" disguised as exams. Another interesting possibility would be to allow real traders to use the system for "mock" portfolios to be carried as alternatives to their portfolios and to carefully monitor their efforts.

Concluding, the efficient market research area of accounting has produced interesting and potentially useful results; now it is the time for accounting researchers to explain how the combination of individual information processing differences and available information leads to an efficient market.

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