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ABSTRACT

Business decision makers were asked to evaluate and use various information reports, as might be supplied by an information system, in several decision making scenarios. Multi-dimensional scaling was utilized to detect underlying perceptual dimensions of the information (differentiation ability), and to assess the importance or salience placed on each of these various dimensions (discriminant ability). Preference mapping was utilized to assess the underlying decision rules used by the decision makers in using the various information items in decision making tasks. As expected, individual differences were found with respect to differentiation, discrimination, and integration abilities. However, further analysis demonstrated that relatively homogeneous groupings of decision makers could be formed which utilized information in decision making in a similar manner. The implications of the study indicate that information systems designers need to consider the cognitive characteristics of decision makers, and that information reports may be tailored to relatively cognitively homogeneous groups of design makers who perceive information in the same manner.

INTRODUCTION

Information systems specialists are not only interested in their traditional role of supplying information and in making decisions regarding the manner in which it is supplied, but more recently have become interested in the decision making process. Information specialists can no longer say that their job is merely to generate data and to report the facts, because the facts they report and the way they report them determine the actions that the recipients of the reports will take. Consequently, information systems specialists should consider the recipient action required and/or desired before effective system outputs can be designed.

OVERVIEW OF HUMAN INFORMATION PROCESSING AND DECISION MAKING

Evaluation of the ways in which decision makers process information is a necessary step toward realization of the goal of improved information systems. This evaluation may include analysis of message or information attributes, the social environment of the decision making process, and the individual decision maker's personal characteristics and attitudes. For example, individual characteristics to be considered may include perceived source credibility of the message, risk attitude, problem familiarity, personality characteristics, values, attitudes, intelligence, modes of perception, modes of encoding of

information, strategies in the remembering of information, modes of thinking, and modes of problem solving. The general objective of the current research study is to evaluate some of the cognitive factors that affect the information processing of business decision makers. Specifically, this study focuses on the decision maker's modes of perception of information. An underlying postulate is that what is perceived as information by one decision maker may not be perceived as information by other decision makers. Further, as information is differentially perceived, it may also be differentially preferred (used) in the design making process. This postulate has implications for the modes of presentation of information to decision makers by the information systems.

In the next section of this paper, an overview of human information processing and decision making is presented which develops a foundation for the subsequent sections of the paper. These sections contain the research questions, research methods, results, and summary and directions for future research, respectively.

OVERVIEW OF HUMAN INFORMATION PROCESSING AND DECISION MAKING

A number of research approaches have been utilized for evaluating various information characteristics, behavioral, and other factors by information systems researchers. These approaches are broadly categorized as Information Economics approaches (I/E) and Human Information Processing Approaches (HIP).

The premise behind the I/E approach has been that if information systems specialists, as suppliers and users of information for decision making, are to effectively integrate information models and information systems, a determination must be made of the relative utility of various information sets among users and the ways to economically represent them in the information systems model.

Information economics is primarily an ex ante normative formulation. Thus, information system alternatives, the decision rule, and utility function must each be specified prior to selecting an information system. A major limitation of most I/E formulations is the absence of explicit considerations of human information processing, behavioral variables, and behavioral relationships. A closer examination of research in this area reveals that an implicit Bayesian information processing rule is assumed. Few studies, however, have investigated the specification error that may exist if other processing rules and behavioral variables are more representative in extant information choice situations. This leads to a lack of confidence in the predictive validity of payoff differences which are forecasted from typical I/E studies (Mock & Vasarhelyi, 1978).[1]

While the I/E model concentrates on the major elements of information and decision processes, the HIP models emphasize human information processing elements. In HIP studies, researchers are typically concerned with a judgment model and the characteristics of a given decision maker. The ability dimensions encompassed in the model essentially refer to the content of cognition or the question of what kind of information is being processed by what operation and in what form (Messick, 1973).

Human information processing under uncertainty may be characterized as a probability-revision process affected by the receipt of information. This probability-revision process has been typically

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[1] Mock and Vasarhelyi (1978) provide a framework for integrating or synthesizing the information economics and human information processing models. This is further discussed by Hilton (1980, 1981).

studied through use of the Brunswick lens model approach, which attempts to model the "content" or ability dimensions encompassed in the model.

Cognitive Styles/Cognitive Complexity Approaches to HIP

Supplemental HIP approaches (to the lens approach) include the evaluation of cognitive styles and cognitive complexity. These approaches are considered to be determinants that affect the probability-revision process.

In cognitive styles, the focus is on the impact of the decision makers' characteristics on components of the decision rule in information processing. In this research, an attempt is made to categorize decision makers according to their cognitive differences or, more specifically, according to their style of information processing. These styles are typically determined through the administration of psychological instruments (tests) designed to measure various personality constructs. For the most part, cognitive styles are information processing habits that develop in congenial ways around underlying personality trends. Cognitive styles research has been given a good deal of attention in the information systems literature and a synthesis is found in Zmud (1979). Cognitive complexity research has focused on problem-solving approaches used by decision makers and the number of different dimensions or constructs utilized by subjects in judging similarities and differences among people, or objects (Messick, 1973).

Because stylistic consistencies frequently interact with the ability dimensions (content of cognition factors modeled by the lens and I/E approaches) to influence the achievement level of performance, the cognitive styles/cognitive complexity research approaches are based on evaluating the style of cognition or the question of "how" (i.e., the manner in which behavior occurs). For this reason, it is important to assess the style of response to cognitive demands as well as the content of the response. The concept of the ability dimensions (content of cognition) of the decision makers, represented by the lens and I/E approaches, implies measurement of decision makers' capacities in terms of maximal performance, whereas the concept of style implies the measurement of preferred modes of operation in terms of typical performance.

Controlling Mechanisms of Personality Related to Cognitive Complexity

Stylistic aspects of cognition reflect personality dimensions that cut across affective, personal-social, and cognitive domains and thereby serve to interweave the cognitive systems with other subsystems of personality organization. The personality dimensions of primary interest in this reference are "controlling mechanisms," which are the structural dimensions of personality that determine the characteristic regulation and control of impulse, thought, and behavioral expression. These controlling mechanisms include such variables as cognitive styles, coping styles, attentional propensities, and defenses. Some of the controlling mechanisms represent dimensions of individual differences in the structural characteristics of the cognitive system itself. These dimensions primarily reflect differences in the complexity of the system.

Several measures of individual differences in cognitive complexity have been evaluated. These measures include the number of different dimensions or constructs utilized by subjects in judging similarities and differences among people, the degree of graduation or articulation within each of these dimensions, the diversity of content exhibited in the concepts generated, the number of different groups used in sorting

common objects, and the abstractness versus concreteness of conceptual systems (Martindale, 1981; Watkins, 1981).

The notion of cognitive complexity has been fully explicated in a variety of ways in the psychological literature. Common to all formulations of cognitive complexity are the dimensions of differentiation (the number of attributes used by an individual to identify an object or event), discrimination (the assigning of slightly varying stimuli to the same or different categories), and integration (the organization of the descriptive attributes). Therefore, an individual's level of complexity is the degree to which a simple or complex structure is exhibited toward a particular object, irrespective of content.

A low complexity individual is characterized by categorical black-white thinking, lack of insight into new or different aspects of a a situation, minimization of internal conflict, and absolute and rigid rules of integration. High complexity individuals exhibit a greater ability to see nuances and a greater willingness to modify their positions.

Difficulties with Cognitive Complexity Research from an Information System Perspective

In the cognitive complexity area, very little attention has been given to identification of the different perceptual dimensions utilized by decision makers in judging similarities and differences among information cues. Further, the degree of gradation or articulation within the dimensions has been largely ignored. Empirical studies by information systems researchers are practically nonexistent in the cognitive complexity area.[2]

[2]Exceptions to this statement include the pioneering study of Driver and Mock (1975).

These research deficiencies are especially troublesome since cognitive psychologists have demonstrated that perception is a key element in the decision making process. Perception affects the way in which information is encoded and represented in memory and is an active response process. This means that perception involves the active construction or synthesis of a model of the world rather than the passive reception of pictures of the world. Thus perception involves the activation of a schema or category in memory (Glass, Holyoak, & Santa, 1979; Laird-Johnson & Wason, 1979; Lachman, Lachman, & Butterfield, 1979; Martindale, 1981; Rosch & Lloyd, 1978).

Information systems researchers Mason and Mitroff (1973) and Kilman and Mitroff (1976) seem to recognize the potential effect of perception on decision making when they argue that what is information for one individual will definitely not be information for another. They further argue that a goal of an information system is to give each individual the type of information the person is psychologically attuned to and will use most effectively. While intuitively appealing and consistent with the empirical results of cognitive psychology, these propositions have not been empirically tested in an information systems context.

The present study attempts to provide understanding of decision maker perceptions of information and the manner in which decision makers differentiate, discriminate, and integrate available information and the resulting implications for information systems design.

RESEARCH QUESTIONS

The above objectives of the study can be expressed as a series of research questions. These are based on a premise of the study that effective decision making is, to a great extent, dependent on the decision

makers' perceptual ability to differentiate, discriminate, and integrate the available information sets.

These research questions are:

1. How do decision makers differentiate a given information set?

2. Are there significant interindividual differences in information discrimination?

3. Are there commonalities among decision makers that allow a nomothetic approach for evaluating decision outcomes (integration issues)?

RESEARCH METHODS

In order to assess each of the research questions, data were gathered from executives of twenty-three corporations. These executive decison makers represented industries including banking, utilities, manufacturing, housing, forest products, petroleum, and other business-for-profit firms.

These decision makers were asked to make similarities judgments among sixteen information reports. These reports consisted of economic, financial, technological, social, political, legal, and marketing information.

The information sets were presented to the decision makers in a variety of ways (e.g., quantitatively, qualitatively, and behaviorally). Justification for the diversity of content and modes of presentation was to allow assessment of the ability of decision makers to differentiate, discriminate, and integrate the information sets.

Information Reports

The first two research questions focus on an evaluation of the perceived dimensionality or structure of the information that might be supplied to decision makers. As previously stated, Mason and Mitroff (1973), and others have presented arguments which postulate that what is information for one individual will definitely not be information for another. For example, Mason and Mitroff (1973) postulate four information sets: (1) symbolic; (2) raw data, hard facts, numbers; (3) imaginative stories, sketches of future possibilities, and (4) art poetry, human drama, moralistic stories. They argue that decision makers are more attuned to one type of information at the exclusion of the other types. This notion is consistent with the cognitive complexity concepts of differentiation and discrimination. That is, differentiation refers to the number of attributes (dimensions) perceived in the information set whereas discrimination refers to the saliences or importance weights that are applied to the perceived attributes or dimensions.

For example, in the Mason-Mitroff model, a given decision maker may perceive an information report as containing "symbolic" and "hard facts" information. The decision maker may perceive both dimensions of the information report or perceive the report as being unidimensional. If the information perception is multi-dimensional, the decision maker may primarily rely on (weight) one or more dimensions for most decision making activities. This is because the decision maker's perceptual cognitive system is more attuned to assimilating and dealing with a particular kind of information to the relative exclusion of other types.

In the present sudy, the empirically developed structure of intelligencce model (Guilford, 1967, 1973; Guilford & Hoepfner, 1971) was used to develop mode of presentation dimensions for the information reports. These modes of presentation dimensions are semantic, symbolic, and behavioral and represent the basic sub-

stantive kinds of information from the psychological point of view (Guilford, 1973). The semantic represents information presented in the form of expressions: sentences, words, phrases. This information is generally qualitative. The symbolic represents the more traditional numeric or quantitative information. The behavioral category reflects information that conveys attitudes or feelings of those not involved in the decision making process. Thus, the information reports contained economic, technological, social, political, financial, marketing, and legal information, each presented semantically, symbolically, and behaviorally.

The decision makers were asked to make similarity judgments among the information reports. The criteria for similarity were not specified but left to the discretion of the decision makers.

The resulting similarity judgments were then analyzed for consistency (transitivity) and then through use of multidimensional scaling. Multidimensional scaling, broadly speaking, is concerned with portraying psychological relations among stimuli--in this case, empirically obtained similarities judgments. That is, in this approach, one attempts to represent psychological distance as some type of geometrical distance. The axes or some transformations of the geometric space are assumed to represent the psychological bases or attributes along which the decision maker compares stimuli. As such, these psychological scales can be readily apparent for developing psychological counterparts to various physical scales that the researcher views as relevant to discrimination judgments.

This approach, then, is directed toward research questions one and two, attempting to find the dimensions of differentiation and discrimination among information stimuli. The INDSCAL (Individual Difference Scaling) model (Carroll & Chang, 1970) was utilized. Briefly, this model postulates a group or "master" stimulus space that contains all dimensions (attributes) that are relevant for the total group of decision makers. Different decision makers are assumed to weight these "master" dimensions differentially in judging similarities among pairs of stimuli. Using N individuals' similarities judgments of n (n-1)/2 stimulus pairs, INDSCAL solves for the group stimulus space and a set of decision makers' saliences for each dimension of the group space.

The square roots of the saliences can then be applied to the group stimulus space to yield a private or idiosyncratic space for each decision maker. On the basis of these weights, the decision makers may be clustered or otherwise related to other characteristics that are hypothesized to account for individual differences in perceptual dimensions. Since INDSCAL provides a unique orientation of the group-stimulus space, a simple two-variable correlation can be used to appraise the accuracy of the original multidimensional scales.

To evaluate research question three, relating to cognitive integration, decision makers were asked to consider three decision making scenarios. They were asked to make a decision and to specify the information preferred (used) (from the information reports) in arriving at their decisions. These preferences for information reports were then mapped into their perceptual space (of information reports established by INDSCAL) to evaluate how they integrated the various information reports in decision making tasks. The PREFMAP (preference mapping) model (Carroll & Chang, 1969) was used to aid in evaluation of this issue. This model permits the identification of two levels of preference type segments based on communality in regard to information cue dimension salience (now in context of preference) and, given this communality, communality of ideal-point (or vector)

location in the decision makers' differentially stretched perceptual space.

The PREFMAP method postulates a hierarchy of four models ranging from a point-vector model to various point-point models. The objective for use of the PREFMAP method in this research is to determine if decision makers can generally be described in terms of integrative ability (the rules or models used when relying on information to render a judgment).

RESULTS

Table 1 shows the correlation coefficients from the INDSCAL analysis for the underlying information dimensions of 1 to 5 and 10. These coefficients show the strength or occurrence of the relationship between the derived dimensions and the original data. For example, a high correlation on dimension one would indicate that one dimension reflects most of the information contained in the similarities judgment. Increased magnitude of the correlation coefficients on additional dimensions would indicate the use of additional dimensions to reflect the underlying data structure.

As shown in Table 1, some decision makers utilized as few as two dimensions in assessing the information sets and others as many as five or ten dimensions. One decision maker appears to use as few as two dimensions; four decision makers rely on three dimensions; six decision makers use four dimensions; and eleven decision makers utilize five dimensions in assessing the supplied information reports. These results indicate that different levels of differentiation are present, even among a class of decision makers which could be expected to be relatively homogeneous with respect to complexity level.

Table 2 shows the weights or saliences that each decision maker places on the resulting dimensions. For purposes of comparison, all decision makers were constrained to a maximum of five dimensions. As can be seen in Table 2, decision makers do exhibit different weightings on the dimensions.

For example, subject one appears to weigh dimensions one and three to a greater extent than the remaining dimensions; subject 13 places most of the weight on dimension three; subject 17 places most of the weight on dimension four; and subject 18 appears to weight all five dimensions somewhat equally, although dimension one receives the greatest weight. Thus, even though decision makers appear to have the ability to perceive varying characteristics in the information, some decision makers relatively ignore some of the perceived aspects of information where other decision makers rely on most or all of the perceived aspects of information (see Table 3).

This indicates that there is a great deal of intergroup discriminant ability with regard to the information reports. To further assess this issue, cluster analysis was utilized to see if groups of decision makers could be formed who had relatively homogeneous salience or weights on the various dimensions. These results are shown in Tables 4 and 5. As noted there, four groups were formed with individual decision makers who share common weights on the dimensions.

Table 5 shows the results of applying the INDSCAL algorithm to each of the four groups separately. The subjects were constrained to a maximum of four dimensions. As noted in Table 6, higher correlations are generally present for the four dimensional solution, when subjects are grouped according to communalities of salience on the dimensions, than when the relatively heterogeneous overall grouped is scaled. This result may have implications for information systems design where a goal may be to tailor reports to classes of decision makers rather than individuals.

Table 1. Individual-Subject Correlation Coefficients from Aggregate Level INDSCAL Analysis of Infomration Cues in Ten, Five, Four, Three, Two and One Dimensions*

Subject	Dimensions 10	5	4	3	2	1
1	.920945	.849263	.854013	.863031	.774037	.763051
2	.868041	.818503	.817134	.810378	.761878	.599205
3	.882043	.859386	.848703	.836653	.805796	.770101
4	.866725	.870149	.865009	.856464	.846219	.671234
5	.807292	.736922	.730617	.735495	.668690	.662360
6	.772665	.677655	.668216	.643417	.598538	.573031
7	.879104	.831435	.817820	.816234	.790320	.691253
8	.799782	.709577	.617565	.422810	.305368	.246844
9	.646143	.461502	.473596	.384863	.156957	.085265
10	.809218	.716393	.697168	.702137	.675201	.567610
11	.832510	.595079	.587719	.563444	.506344	.372408
12	.677124	.587956	.462290	.431941	.303510	.312389
13	.772353	.589703	.480220	.451293	.299999	.273596
14	.796517	.499792	.442774	.444518	.403611	.194416
15	.829359	.785787	.777101	.767200	.717354	.650869
16	.830739	.773487	.768317	.763694	.665688	.658970
17	.799171	.781331	.730225	.325898	.167657	.136450
18	.810660	.800361	.778758	.737374	.670451	.623531
19	.737923	.618723	.621239	.613444	.591555	.360010
20	.808937	.755307	.723785	.709356	.671791	.338994
21	.714560	.600977	.559291	.556553	.548401	.533137
22	.846959	.830706	.820607	.800797	.762095	.546133
Average Subject	.80494	.71591	.68828	.64714	.57672	.48322

*Underscore indicates highest perceived dimensionablity for a given subject.

Table 2. Individual-Subject Dimension Saliences from Aggregate Level INDSCAL Analysis of Information Cues in Five Dimensions*

Subject	Salience on Dimension 1	2	3	4	5
1	.56074	.08946	.48779	.16915	.08701
2	.40079	.48209	.38444	.06636	.19238
3	.58829	.09641	.49935	.03576	.09776
4	.60793	.50248	.20404	.13949	.08379
5	.52200	.03339	.37043	.15224	.14247
6	.43390	.12070	.37606	.04885	.19237
7	.71977	.34979	.05626	.04978	.14480
8	.28782	.13266	.07244	.41712	.44850
9	-.02326	.14685	.22394	.26608	.24210
10	.45703	.46096	.17939	-.01979	.12874
11	.31433	.29661	.24264	.18216	.16642
12	.22460	.00917	.27469	.18713	.38165
13	.02594	.11676	.55067	.04528	.10319
14	.20519	.35408	.08533	.05122	.24220
15	.61388	.32568	.18952	.13939	.13509
16	.49179	.13185	.43583	.12252	.17873
17	.10659	.06973	.08090	.73572	.17669
18	.49948	.27992	.31383	.23153	.26589
19	.34400	.44532	.14203	.11182	.06105
20	.27758	.59746	.17938	.07346	.24833
21	.51877	.01188	.10847	.04772	.22209
22	.62537	.49387	-.00263	.12801	.17760
Average Subject	.41375				

*Underscore indicates most important dimensions.

Table 3. Comparison of Differentiation and Discrimination Abilities of Four Selected Subjects (see Tables 1 and 2)

Subject	Number of Perceived Dimensions (Differentiation)	Dimensions Emphasized (Discriminant Ability)
1	3	1, 3
13	5	3
17	5	4
18	5	1, 2, 3, 4, 5

Table 4. Subject Group Assignments (Homogeneous Groups Based on Discriminant Commonalities)

Group A	Group B	Group C	Group D
8	1	2	4
9	3	10	7
12	5	11	15
17	6	14	22
	13	19	
	16	20	
	18		
	21		

Table 5. Individual Subject Correlation Coefficients from Group A, B, C, and D INDSCAL Analysis of Information Cues

Group A		Group B		Group C		Group D	
Subject	Correlation	Subject	Correlation	Subject	Correlation	Subject	Correlation
8	.784892	1	.898780	2	.806014	4	.860389
9	.557783	3	.884970	10	.776473	7	.880131
12	.717460	5	.799240	11	.631171	15	.858032
17	.841983	6	.685957	14	.775554	22	.875333
		13	.762444	19	.687197		
Average		16	.783808	20	.812996	Average	
Subject	.895152	18	.735532			Subject	.968898
		21	.702496	Average			
				Subject	.934877		
		Average					
		Subject	.963838				

Table 6. Comparison of Correlations from INDSCAL Analysis Between Overall (Heterogenous) Group of Decision Makers and Four Relatively Homogeneous Groups of Decision Makers Based on Commonality of Dimension Salience

Subject	(4-Dimension Solution) Overall group	Homogeneous Subgroups
1	.85	.90
2	.82	.81
3	.85	.88
4	.87	.86
5	.73	.80
6	.67	.69
7	.82	.88
8	.62	.79
9	.47	.56
10	.70	.78
11	.59	.63
12	.46	.72
13	.48	.76
14	.44	.78
15	.78	.86
16	.77	.78
17	.73	.84
18	.78	.74
19	.62	.69
20	.72	.81
21	.56	.70
22	.82	.88
Average Subject	.69	.94

Results in support of research question three show that the decision makers can generally be modeled using simple vector or ideal point models, and that the mapping of preference into the information differentiation dimensions does little to change the original emphasis on the dimensions.[3] In some cases, the mapping does refine or give more weight to some dimensions for some decision makers, thus enhancing the dimension. In essence, decision maker integrative ability seems directly related to discriminate ability. Based on these results and the results in support of research question two, it appears that sufficient commonalities exist to be able to postulate a nomothetic approach for the tailoring of information reports to users. That is, individual differences may be ignored to a certain extent, provided that relatively homogeneous groups are formed which are composed of cognitively similar members.

SUMMARY AND DIRECTIONS FOR FUTURE RESEARCH

This study has been an attempt to use the measurement techniques of multidimensional scaling and preference mapping to examine the relationships between cognitive complexity and perception.

This research study suggests that a multimethod, multivariate approach is desirable to understand the complex nature of the cognitive system. Further, it demonstrates the ability of the decision makers to differentiate, discriminate, and integrate the information set used for decision input.

This study looks at only one series of decision scenarios. More research should be undertaken to assess the nature of complexity levels to see if they are task specific or universal across decision tasks.

Further, perhaps more research should be undertaken by information systems researchers with respect to cognitive complexity and its potential effects on decision outcomes. Many of the studies in psychology have shown greater correlation between cognitive complexity constructs and decisions outcomes than between cognitive styles constructs and decision outcomes. This further amplifies the previous implications that more knowledge is needed about the relationship between cognitive styles and cognitive complexity. Information systems designers need to be aware of these issues and the potential impact on the decision making process.

[3] Detailed statistics and other supporting data in support of these results are found in (Watkins, 1980).

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