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Differential Effects of Cognitive Complexity on the Organization of Management Information

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Recently there has been extensive research into how individuals process information by psychologists (Sieber and Lanzetta, 1964; Karlins and Lamm, 1967; Schroder et al, 1967) and management scientists (Bettman, 1971; Howard and Morgenrath, 1968; Cravens, 1970). Yet, despite the scope and intensity of this general effort, little is known about how managers differ in the ways they prefer their information to be organized.[2] One characteristic that has been successfully used to differentiate several other aspects of an individual's information handling is the complexity of his conceptual structure (Schroder et al, 1967). Individuals who are cognitively complex have been found to differentiate more aspects of their environment and to track information that is not readily available when playing a management game. They have also bee found to integrate more discrepant information than have cognitively simpler subjects (Schroder et al, 1967, Chapter 8). It is therefore possible that conceptual structure may also be a determinant of how managers prefer their information to be organized and hence may be an individual difference of significance to accountants undertaking the design of reports for managers. The purpose of this study is to evaluate this possibility by examining the relationship of cognitive complexity and information organization.

Cognitive Complexity and the Organization of Information

Psychologists believe that an individual processes an information set by assigning to its elements different characteristics or different levels of the same characteristic. Thus, the way in which an individual copes with information depends on the number of characteristics (dimensions),

the number of levels (gradations) within each characteristic and the complexity of the interrelationships among the characteristics he has available (Schroder et al, 1967). The relationship that exists among these cognitive components at one point in time is termed a cognitive structure, defined as "... any form of interdependence among cognitive elements ... which has motivational, affective, attitudinal, behavioral or cognitive consequences" (Zajonc, 1968, p. 321) or, simply an " ... organized representation of prior experiences" (Neisser, 1967, p. 287). An individual's cognitive structure, therefore, can be regarded as an intervening variable in the process of interpreting and integrating information. Psychologists are interested in cognitive structural properties because they believe that while cognitive content can vary infinitely, structure is more invariant and enduring over situations (Scott, 1963).

Cognitive structures have been differentiated by such polar adjectives as complex - simple (Bieri, 1955), abstract - concrete (Harvey et al, 1961) or flexible - rigid (Adorno et al, 1950), all of which are conceptually interrelated. An individual possessing a complex cognitive structure is believed to have available a more differentiated construct system, e.g., more dimensions and more gradations within dimensions with which to discriminate among stimuli. He is believed to be more receptive to new phenomena because of his greater discriminatory ability and to possess greater analytical ability because he employs a broader classification scheme with more relationships potentially available. Therefore, he is believed to be capable of discriminating information to a greater extent and to process it in more complex ways. Based on this

interpretation of cognitive complexity it is apparent that an individual's conceptual structure may also affect the way he prefers his information to be organized. Therefore, the conceptual structure of a report user may be a parameter of significance to accountants engaged in designing reports.

An accountant faced with designing a report format must make several important decisions. For example, he must decide if the total information set should be formatted into a single, all encompassing report or be segmented into several reports; if all segments should be of relatively equal size or if the sizes of the segments should vary; or if the elements within each segment should be interrelated as simply as possible (e.g., summarized) or be combined in a somewhat more complex fashion. Traditionally these decisions have been based on the content of the information involved or on the expected use of the report and no consideration has been given to the report user's cognitive characteristics. To test the possibility that the information user's cognitive complexity should also be considered when making these decisions the following hypotheses are proposed.

HYPOTHESES

H-1: Cognitively complex individuals possess a greater ability to integrate a number of diverse aspects at one time than do cognitively simpler individuals. Thus, for a given number of information elements, cognitively complex individuals prefer their information to be organized into fewer segments containing a greater number of information elements in each segment.

H-2: Cognitively complex individuals differentiate all the diverse

elements of their task domain more evenly than cognitively simpler individuals. Thus, for a given amount of information and number of segments, cognitively complex subjects prefer their information to be distributed evenly among segments.

H-3: Cognitively complex individuals integrate the diverse aspects of their environment in more complex ways than cognitively simpler individuals and hence, prefer their information to be organized into more integrated structures

METHOD

Subjects

Subjects were sales supervisors, district sales managers and regional sales managers of a large integrated oil company who were selected because of their familiarity with one of the two district sales managers jobs which were used as focal roles in this experiment. In all 44 subjects with mean age of 40.0 years participated, exactly half of whom were university graduates.

Procedure

Since a report can be regarded simply as a pattern into which a set of information elements is organized it is assumed that the report format an individual prefers closely approximates the way he would organize the information himself if he had the chance. Therefore, rather than prescribe report formats, each individual was allowed to organize his information as he desired and measures of organization were based on the structures each individual generated. The following instruments and

procedures were used.

In preliminary consultations with a representative sample of sales managers in each of the two jobs a number of aspects related to their jobs were discussed and recorded. From these aspects, a set of 72 items was selected for each job and were classified[3] by three managers not participating in the study to ensure that equivalent items were used for both jobs.

The items were printed on 1-1/2" x 2-1/2" cards which were numbered randomly and a deck of these cards was used in an experiment as follows: Subjects were presented with the deck and a questionnaire in which to record their results. One page of the questionnaire had a diagram of a nine column normal-shaped histogram, marked off into 72 equal squares (see Figure 1). Subjects were instructed to look through the deck thoroughly and then to sort the cards into a distribution identical to that in the diagram, using as the criterion the importance of the items to them, assuming that they were required to perform the manager's job and would perform it as they believed it should be performed. When the sort was completed, the subjects recorded their sort on the diagram to insure that the required distribution was generated. Next, they were instructed to reassemble their deck and to resort the cards into groups, using their own criteria for determining which cards belonged together and to generate as many groups as they felt necessary. Each group was then to be labelled and the groups ranked in order of their importance.[4] Again, the results were recorded. A second questionnaire containing a battery of cognitive tests was then administered.

FIGURE 1 ABOUT HERE

Because of the geographic dispersion of the subjects involved, the procedure was designed to be as self checking as possible and was completed without the experimentor present. Only one of the subjects contacted improperly completed the procedure.

Measures of the Organization of Information

The 72 items sorted were scored 9 to 1 depending on which column of the histogram they were placed in. The most important items received a score of 9. Using these data and the item groupings formed by the subjects the following parameters were derived.

Segmentation: This parameter is intended to reflect the extent to which a set of data is segmented. The measure used was the number of groups an individual formed.

Balance: This parameter reflects the relative sizes of the data set segments and was measured from the groups the subjects formed. Balance was computed as the square root of the product of the sums of the squares of the number of elements in each group times the number of groups used. This latter factor removed the biasing effects of the number of groups and the measure is a relative one.[5] The more equal the groups are in size the smaller the numerical value of the measure.

Integration: This parameter is intended to measure the complexity of the interrelationships among the information elements that make up the segments. The degree of integration was measured in two ways which are labelled complexity and interaction.

a) Complexity of Organization: This measure of integration is based on the assumption that the degree of complexity of an information structure is a function of the number of conceptual interrelationships

among its component elements.

The measure is based on the degree of similarity that the classification scheme a subject used in assessing the importance of information has with the scheme he employed to assemble information elements into groups. If the processes of sorting and grouping are based on very similar conceptual schemes the importance of each element also dictates what group it is placed in. Grouping itself does not involve adding any additional conceptual relationships. Thus the number of interrelationships among the elements in a segment is minimal. In fact, if summarization is defined as a report generating process where information is organized based on importance, it is apparent that segmenting information in this way is very similar to the process of summarization.

On the other hand, if the processes of sorting and grouping are based on two different conceptual schemes the basis for determining the importance of an information element and the basis for determining which group it should be placed in are not identical. In this case the data are not merely segmented by importance. Rather, there exists interrelationships among the elements in each group that depend on a classification scheme other than that used in the importance sort. In this case the elements are more complexly interrelated. These two possible forms of information organization are illustrated in Figure 2.

FIGURE 2 ABOUT HERE

Complexity was measured by computing an F statistic as if testing the difference between group means. The scores assigned to each informational element based on the importance sort were used as data. For

those subjects primarily employing one basis for classification, the order of elements in the importance sort influences the grouping of the items. Thus, high scores will appear in one group, next highest in the next group, and so on yielding a high F ratio. On the other hand, if the elements are grouped randomly with respect to their position in the importance sort, groups would tend to have equal means and larger within group variances, and a lower F ratio would result. A high score on complexity therefore indicates low integration.

b) Interaction: A second measure of integration is based on interaction effects. When the individual information elements were sorted, each was judged to have some relative degree of importance attached to it. But these items are also used to form groups and each group as a whole was also assigned a relative importance. If there are no interaction effects, that is, if the relative importance of the component elements of a group stay the same regardless of whether or not they are considered independently or considered in conjunction with other elements of that group, the average importance of the elements within a group should determine that group's relative rank. If there is interaction however, the importance of a group may not be the aggregate importance of its elements but be determined by the extent to which the individual elements interact with one another. Interaction is the extent to which the importance of individual items is modified by their relationships with one another. An individual's organization of information is integrated when it contains high levels of interaction.

Interaction was measured by the correlation of the rank of a group with the average importance of the items in it times -1. The lower the

correlation the higher the interaction.

In proposing these measures of the organization of information, it must be pointed out that some of these (complexity and interaction in particular) have the inherent weakness of confounding complexity with randomness and inconsistency. They are therefore most useful in disclosing the absence of complexity rather than the presence of it.

Measures of Cognitive Complexity

Beyond agreement on the notion that cognitive structures are composed of elements and their interrelationships, there is diverse opinion as to what are the elements that make up the structures and, in what ways are they organized. Hence, there is considerable disagreement as to how cognitive complexity should be measured (Zajonc, 1968; Scott, 1963). In addition there has been considerable disagreement as to whether an individual's cognitive complexity is a general personality trait, whether it is specific to a particular domain and, if so, what constitutes a domain (Scott, 1963; Vanoy, 1965; Evans and Dermer, 1971). Because at the present stage of construct development it is impossible to reconcile these diverse opinions, three measures presumed to reflect a manager's tendency to be cognitively complex in his working environment were used. These were:

Dogmatism:

The short form (Troldahl and Powell, 1965) of the scale developed by Rokeach (1960) was used as a measure of authoritarianism and the extent of openness of the belief system. Openness of the belief system is an indicator of "... the extent to which an individual can receive,

evaluate and act on relevant information received from the outside on its intrinsic merits, unencumbered by irrelevant factors in a situation arising from within the person or the outside" (Rokeach, 1960, p. 51). High dogmatics are more likely to be influenced by perceived authorities, not to seek wider knowledge, prefer concrete facts, have difficulty integrating discrepant information and to think in terms of stereotypes (Ondrack, 1971).

Intolerance of Ambiguity:

The scale developed by Budner (1962) was used. Ambiguity arises in situations characterized by novelty, complexity or insolubility. Individuals intolerant of ambiguity perceive ambiguous situations as a source of threat and responses to threat include repression, denial, or avoidance behavior (Budner, 1962). A high score on this measure is interpreted to mean that a subject is intolerant of ambiguous situations.

Esteem for the Least Preferred Co-worker (LPC):

The most recent version (Fiedler, 1967) consisting of 16 items was used. The average score is the LPC score. High LPCs are assumed to differentiate between personal attributes relating to an individual as an individual and personal attributes relating to an individual as a task co-worker. LPC has been suggested as a measure of complexity in several studies (Mitchel, 1970; Bieri, 1961; Schroder et al, 1967).

RESULTS

The intercorrelations between the cognitive measures and the measures of information organization are presented in Table 1. To consider the possibility of curvelinear relations as suggested by the

results of other studies (Bieri, 1955; Evans and Dermer, 1971) the sample was split at the mean of each cognitive measure also.

H-1: Cognitive complexity and the number of groups formed.

This hypothesis was supported only by the low LPC sample half ($p < .06$). Both the dogmatism and ambiguity correlations indicate that the underlying relationship are non-linear.

TABLE 1 ABOUT HERE

H-2: Cognitive complexity and balance.

The relationship with the LPC measure is significant overall ($p < .05$) and for each half ($p < .05$) separately, but in a direction opposite to that expected. It appears that complex individuals, as measured by the LPC test, prefer far less relative balance in their information segments than do low LPCs. The high ambiguity sample half correlation of -.33 ($p < .10$) provides additional support for this finding.

H-3: Cognitive complexity and integration.

With respect to complexity of organization the hypothesis was supported only by the high ambiguity sample half correlation ($p < .05$). Interaction shows no significant correlation with any of the measures. Therefore, H-3 is taken to only be partially supported. The correlation with the LPC sample halves indicates that a significant non-linear relationship exists.

DISCUSSION

Based on these results it appears that intolerance of ambiguity measure is most closely related to the way the manager structures his

information. Neither the dogmatism nor the least preferred co-worker (LPC) measure was consistently found to be related. This absence of strong intercorrelation between all cognitive and information organization measures, however, is not altogether unexpected for two reasons. Firstly, in the studies that successfully related complexity to information processing the measures of complexity that were used were based on the projective techniques devised by Schroder et al (1967). These techniques have not been found to correlate with most of the common measures of complexity (Vannoy, 1965). Schroder et al explain this lack of correlation by stating that while these other measures "... are conceptually related to abstractness, particular operational measures of these constructs may fail to assess the integrative complexity property so central to abstractness" (1967, p. 184). Unfortunately this type of explanation sheds little light on what is the essence of their measure and the relationship between Schroder et al's work and that of other cognitive theorists remains a mystery.

Secondly, while the three measures used in this study were assumed to be conceptually related, the intercorrelations between them (Table 2) only substantiates this for the dogmatism and ambiguity measures. These findings can be interpreted to further support the belief that cognitive complexity is not a general disposition (Vannoy, 1965). Furthermore they indicate that considerable more construct validity will have to be achieved before cognitive complexity can serve as an individual difference measure useful in predicting the way a manager prefers his information to be organized.

TABLE 2 ABOUT HERE

The findings that high dogmatics did not organize their information into simpler structures however is particularly surprising. Although several subjects indicated displeasure with the content of the items of the dogmatism scale, its significant correlation with ambiguity indicates that it was seriously completed. The only explanation that can be offered for this result is that perhaps the content of the items is a significant factor and the measure is not generalizable to the task domain. Schroder et al (1967) note that Harvey reached a similar conclusion in a study involving role playing (p. 134).

The intercorrelation among the measures of information organization are presented in Table 3. As is to be expected, the two measures of integration, complexity and interaction, are interrelated. Of these two, only complexity has a cognitive correlate (with the high ambiguity sample half).

TABLE 3 ABOUT HERE

Balance is correlated with ambiguity. From this result it appears that poor tolerance of ambiguity results in a hedging process that serves to keep the segments in balance. Balance also relates significantly to complexity while interaction relates to balance alone and then only at the $p < .15$ level. This indicates that the more balance the less interaction which is consistent with the finding that balance is a characteristic of simpler subjects. Interaction correlates with ambiguity at the probability $< .20$ level only, however.

From these results it appears that subjects who are cognitively simple tend to segment their information to a greater extent, tend to

use information structures which are balanced, less complex and possess little interaction. Except for the findings with respect to balance, these are the expected characteristics of simpler information structures. Therefore to the extent that the ambiguity tolerance and LPC measures are indicators of cognitive complexity, there is some support for the belief that cognitively simple subjects do organize their information into simpler structures.

SUMMARY AND IMPLICATIONS FOR FUTURE RESEARCH

This study attempted to determine if individual differences in cognitive complexity are determinants of the way a manager prefers his information to be organized. A set of parameters describing the organization of information were proposed, measured and related to three measures of cognitive complexity. It was found that the intolerance of ambiguity and esteem for the least preferred co-worker measures were related to the measures of information organization. Specifically, it was found that low LPCs tended to segment their information to a greater extent than did high LPCs. High LPCs and individuals tolerant of ambiguity were found to group their information in a far less balanced way than were other subjects. It was also observed that subjects who indicated a poor tolerance for ambiguity structured their information less complexly. Therefore, it was concluded that cognitively simple subjects do organize their information into simpler structures.

The results of this study indicate that the conceptual structure of a report user is a factor that should be considered by accountants

when designing reports for managers. Thus, when faced with formatting a set of data concerning, for example, a number of product lines selling in a number of territories, accountants should make use of the fact that cognitively simpler managers prefer the data broken up into a greater number of segments than do their more complex colleagues. In addition, since simpler managers appear to prefer to have information elements grouped according to importance, it is possible that the best format consists of one report containing, for example, contribution margin data for all products, with the remaining data organized into supporting reports of decreasing importance. Answers to such specific questions as to what extent should data be segmented or what should be the basis for clustering information, however, are beyond the scope of this study.

This study has raised several questions that are worthy of further investigation. For example, the weak interrelationships among the four measures of information organization with each other implies that there are at least four independent parameters to describe a report. How many parameters are actually needed in total and which parameter is most useful in predicting performance remains unanswered however. In addition, the lack of complete and significant correlation of the measures of information organization with any one measure of cognitive complexity indicates that there are underlying relationships are not straightforward. Which measure of conceptual structure is most useful in investigating questions of information organization, therefore remains to be answered. And finally, the whole question of the effects of improperly matching information organization and cognitive complexity on task performance is open to investigation. Therefore, while the measures and interrelationships examined in this study have provided

a first step toward understanding the relationship between a user's conceptual structure and the structural aspects of information provision, further investigations are required if accountants are to enhance their understanding of this phase of the information provision process.

TABLE 1: CORRELATION OF MEASURES OF INFORMATION ORGANIZATION WITH COGNITIVE MEASURES

	Dogmatism			Ambiguity			LPC		
Measure	All n = 44	Hi n = 21	Lo n = 23	All	Hi n = 22	Lo n = 22	All	Hi n = 24	Lo n = 20
Number of groups	.13	.03	-.29	.08	-.16	-.16	.23	-.08	.37+
Balance	.18	.09	-.02	.11	-.33+	-.21	.29*	.52**	.42*
Complexity	.06	.09	.10	-.11	.41*	-.05	-.12	.39*	-.65**
Interaction	-.08	.22	-.17	-.18	-.23	.01	.08	.06	.06

+ $p < .10$

* $p < .05$

** $p < .01$

TABLE 2: INTERCORRELATIONS AMONG COGNITIVE MEASURES

n = 44

		1	2
1.	Dogmatism	-	
2.	Ambiguity	.35*	-
3.	LPC	.01	-.09

* $p < .05$

TABLE 3: INTERCORRELATIONS AMONG MEASURES OF INFORMATION ORGANIZATION

n = 44

		1	2	3
1.	Number of groups	-		
2.	Balance	.13	-	
3.	Complexity	-.17	-.42**	-
4.	Interaction	.16	-.20	.36*

* $p < .05$

** $p < .10$

FOOTNOTES

1. The comments of M.G. Evans, R.I. Simon and Joshua Ronen on an earlier draft of this paper are gratefully acknowledged. The support of the cooperating company and the participation of its managers is appreciated.

2. There has been little attention focused on the relationship between the organization of information and subsequent task performance or decision making. One significant contribution however, is the study of Huysmans (1970) relating the manner of information provision to decisions regarding acceptance and implementation of O.R. proposals.

3. Each item was classified according to time (current or future), scope (internal or external to company boundaries) and measurement (financial, behavioral or other). This scheme has been frequently used to categorize management information (Dearden and McFarlan, 1966). Inter-rater reliability was 95%.

4. Both labelling and ranking were required to insure that groups were functionally distinct from each other in the mind of the subject.

5. This measure ranges from a low of 72 for groups of equal size to a high of approximately 100. For example, for equal groups of 1, 6 or 12 each, the measure would be

$$1 \text{ each} = (72 \times \sum^{12} 1^2)^{1/2} = (72 \times 72 \times 1)^{1/2} = 72$$

$$6 \text{ each} = (12 \times \sum^{12} 6^2)^{1/2} = (12 \times 12 \times 36)^{1/2} = 72$$

$$12 \text{ each} = (6 \times \sum^{6} 12^2)^{1/2} = (6 \times 6 \times 144)^{1/2} = 72$$

For unequal groups the maximum is for two groups of 1 and 71 each. In this case the measure is

$[2 \times (71^2 + 1^2)]^{1/2} \simeq 100$. For any other distribution, the measure falls between 72 and 100. For example, 3 groups of 40, 20, and 12 elements would be measured as 82.

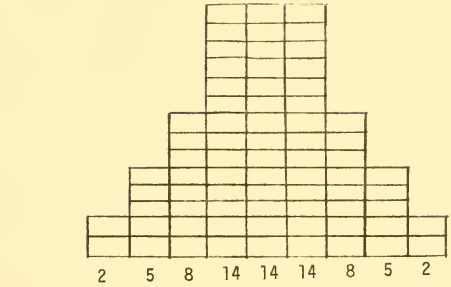
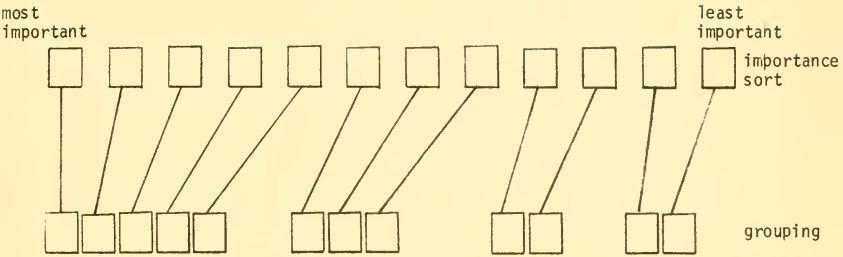
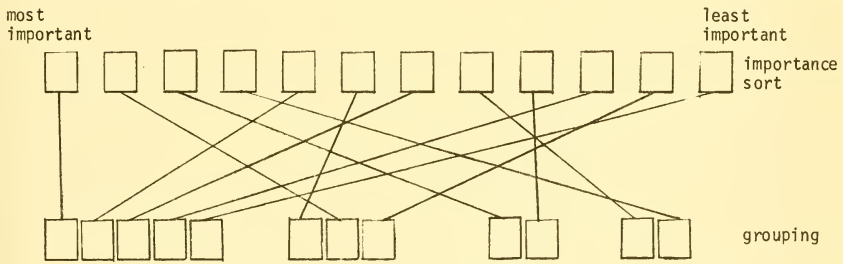


Figure 1 Required Distribution of Cards
(not actual scale used)



(a) Grouping based on same classification scheme use in the importance sort



(b) Grouping based on a classification scheme other than that used in the importance sort.

Figure 2

Possible Relationships Among Items
Between Importance Sort and Grouping of Items

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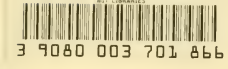

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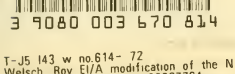

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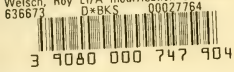

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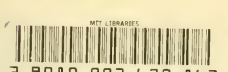

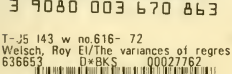

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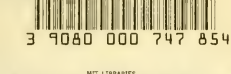

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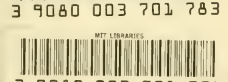

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