COPPEAD/UFRJ

RELATÓRIO COPPEAD Nº 42

THE EFFECT OF ACCOUNTING AGGREGATION ON DECISION-MAKING PERFORMANCE: AN EXPERIMENTAL INVESTIGATION

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Julho 1980

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The purpose of a (management) accounting system is to provide relevant and timely information presented in a manner that is appopriate to user's needs. One important choice made by the information system designer concerns the amount of detail to be incorporated into each accounting report. Too much detail will cause the decision-maker to be overloaded with data and may lead to the quality of his decisions being reduced; too little detail may mean that relevant information is omitted with a consequent deleterious effect on decision quality. The research problem addressed in this paper is to discover whether such a relationship between data aggregation and decision quality exists and, if so how to go about determining the most appropriate level of aggregation for various decision-making tasks.

Although there is general theoretical support for a curvilinear (inverted Ushaped) performance function at successive levels of data aggregation, the tails being caused by information overload when there is little aggregation and by lack of required information at high levels of aggregation, there is lettle or no empirical support for such a hypothesis in the accounting area.[1] Most previous empirical studies (e.g. Barefield [1972], Abdel- Khalik [1973] and Chervany and Dickson [1974]) have merely advanced evidence of low statistical significance) that higher or lower levels of aggregation lead to better or worse performance in certain circumstances. It is thus important to establish whether the hypothesis of a curvilinear performance function can be empirically verified. Such hypothesis is not necessarily inconsistent with this prior empirical work but makes it clear that it is crucial to determine where one is situated on the aggregation scale before predicting the direction in which performance will respond to a change in the amount of aggregation.

In order to test this curvilinear hypothesis, a carefully designed experiment is essential. Particular care is needed to ensure that an adequate range of data aggregation is incorporated,[2] for if the apparently contradictory findings of previous studies are to be reconciled it must be shown that they represent different sections of a curvilinear function. In addition, possible confounding variables must be controlled. To help ensure adequate control, this study follows closely the framework proposed by Dermer [1975] which is built upon Klimoski's [1975] in that it explicitly recognises that decision-making performance is influenced not only by the characteristics of the information provided but the nature of the task being undertaken and by individual differences. One specific variable is identified on each of these major dimensions, namely the level of data aggregation, the complexity of the decision-making task and the cognitive style of the decision-maker. In addition, the study traces decision - making behaviour over time so that the effect of learning may be investigated.

It should be noted that one further factor identified by Dermer [1975], namely organisational characteristics, has been omitted from this study which considers only the behaviour of an individual decision-maker. This should not be taken to imply that organisational factors are considered unimportant, but rather that they are difficult to incorporate into the type of experimental design that is necessary to test the curvilinear hypothesis. It is assumed here that the individual decision-maker attempts to attain the highest level of (personal) performance possible; in an organisational situation this assumption requires modification.[3]

I- RESEARCH APPROACHES TO ACCOUNTING AGGREGATION

The two most commonly used models of the accounting aggregation process are those based on information theory and on information economics. Unfortunately neither of these models provides a satisfactory measure of information loss. More recently models developed by psychologists studying human information processing have been used by accounting researchers and one of these, the cognitive style model, provides a basis for the theoretical development of the curvilinear hypothesis.

I.1. Information Theory

Information theory was first applied to accounting by Lev [1968]. The theory uses the concept of entropy to measure information content; Lev extended this concept to provide a measure for the loss of information caused by accounting aggregation. According to his proposal, the loss of information due to aggregation is measured by the difference between the entropy prior to (H) and subsequent to (H') the aggregation. That is:

$$H - H' = P_s \cdot H_s$$

Where $P_s = P_1 + P_2$ is the combined share of the aggregated items, and

$$H_s = - \left[\frac{P_1}{(P_1+P_2)} \cdot \log \frac{P_1}{(P_1+P_2)}\right] - \left[\frac{P_2}{(P_1+P_2)} \cdot \log \frac{P_2}{(P_1+P_2)}\right]$$

is the entropy of the aggregated items (Lev [1968:252]). This measure of information loss increases both with the size of the aggregated items (in relation to a given total) and with the entropy of each aggregated item.

This approach has been severely criticised on both practical and theoretical grounds. A serious practical limitation of Lev's model is that the selection of candidates for aggregation is external to the model (e.g. accepting traditional account classifications (Bernhardt and Copeland [1970]). Further , the choice of a cut-off point where aggregation should stop is entirely arbitrary (Abdel-Khalik [1974 : 273]). On theoretical grounds, the validity of using fractions as though they were probabilities is questionable (AAA [1971: 316-317]. But the most critical limitation of the entropy model is that it totally ignores the requirements of decision models and the needs of decision-makers and consequently it provides a measure for information loss which is not relevant in itself as has been shown by Ronen and Falk [1973] and Abdel-Khalik [1974]. Thus, information theory cannot be used as a basis on which to make decisions about accounting aggregation.

I.2. Information Economics

Information economics, in contrast to information theory, takes users' decision models and preferences into consideration. As an extension of decision theory, it values information by its effect upon the payoff of the decision involved. The information economics approach has been used for the evalution of alternative accounting information systems by , "*inter alia*", Mock [1971], Demski [1972] and Feltham [1977]. The expected value of using an information system η" is given by the difference between the expected values of the two systems (Demski [1972]). That is:

$$L(\eta', \eta'') = E(\omega \mid \eta') - E(\omega \mid \eta'')$$

where: E is the expected payoff, and

L is the expected loss in payoff.

Feltham [1977] used this approach to examine the consequences of aggregating cost information on the payoffs associated with various decisions. He concluded that, although aggregation may not reduce expected payoff under certain conditions, expected payoff cannot be increased by either summarising or omitting data. Thus, information overload is not admitted as a possible reason for a decline in performance. In addition, the information economics model assumes that the impact of information is limited to probability revision and that the decision - maker revises his probabilities according to Bayes' theorem. Empirical evidence suggest that there are other uses of information (e. g. feedback, learning, attention - directing, scorecard (Mock, [1971]), and that individuals are more conservative in probability revision than Bayes' theorem allows (Slovic and Lichtenstein [1971]). These characteristics of information economics restrict its practical utility in the context of this research.

I.3. Human Information Processing

Recent years have seen accountants seeking a better understanding of the relationship between information and decision -making utilising models developed by psychologists. Although the psychological literature contains numerous models and research approaches, only a few have been applied in accounting research. In particular, use has been made of the lens model, the Bayesian model and the cognitive style model.[4]

i) The lens model

The lens model relies upon regression equations correlation statistics to describe the relationships between information imputs and responses of a decision -maker. This model has been particularly useful in studies concerned with the effect of information on decision rules, cue usage and response accuracy. A typical experiment requires the subject to make a judgement based on a number of informational cues; the cues form the independent variables by which the dependent variable of judgement is explained.

The results of psychological research using the lens model have generally indicated that simple linear models are adequate to explain even quite complex judgements (Goldberg [1968]). Moreover, they reveal that judgements can be greatly affected by informational variables such as the number of cues and the conflict between them. (Hoffman are Blanchard [1961], Slovic [1964], Hayes [1966], and Einhorn [1971]). Within the domain of accounting, Barefield [1972] explored the impact of aggregating cost variance information (Cue reduction) on the quality of the judgement as to whether labour was being used efficiently, although he had failed to show a significant effect. In another study Hofstedt [1972] reported that financial analysts gave increased credibility to the president's letter in a financial report as it became more pessimistic in the fact of increasing earnings per share (cue conflict).

Thus, despite the limitation that the lens model can be applied only to repetitive judgements involving relatively few cues (Einhorn, 1976), the results generated by this approach have some potential for explaining effects caused by accounting aggregation, although it has yet to be fully realised.

ii) The Bayesian model

In the Bayesian approach to human information processing subjects are typically asked to revise the probability of an event occurring, given a new piece of evidence. Bayes' Theorem is used as a normative model to derive an optimal response with which subjects' performance is compared. A range of psychological studies has revealed that human beings tend to display 'conservatism' in their processing of information, explained by Slovic and Lichtenstein [1971: 693] as:

> "Upon receipt of new information, subjects revise their posterior probability estimates in the same direction as the optimal model, but the revision is typically too small; subjects act as if the data are less diagnostic than they truly are".

These findings have led accounting researchers to explore how the quality of individuals' judgement is affected by alternative methods of information presentation. For example, Moskowitz and Mason [1973] observed that both the degree of informativeness and the order of presentation of data significantly affected conservatism in a personal loan-granting decision setting. Dickhaut [1973] also found that subjects given less information showed less conservatism and therefore better performance than those given additional (irrelevant) data.

The general applicability of this approach is limited by the validity of using Bayes' theorem as an appropriate normative model in any particular decision situation. It is, however, valuable in illustrating how normative models can serve as standards against which performance may be assessed.

iii) The cognitive style model

Cognitive style has been defined as a hypothetical construct used to explain the process of mediation between stimuli and responses (Goldstein and Blackman [1978: 2-4]). Cognitive style is normally associated with the characteristic manner in which an individual conceptually organizes his environment. However, there are numerous approaches ranging from an emphasis on the content of thought to an emphasis on the structure of thought. The most popular cognitive style models amongst accounting researchers have tended to emphasise the structure of thought and include cognitive complexity, decision style, the heuristic/analytic model and field dependence.

The cognitive complexity approach considers the capability of an individual both to differentiate stimuli (i.e. to locate them along different dimensions) and to integrate and combine the differentiated dimensions. However, an individual's response to stimuli is viewed not only as a simple function of his cognitive complexity, but also as a function of the level of informational complexity in the environment. According to Schroder, Driver and Streufert [1967] individual performance first increases but them decreases as environmental complexity increases, with more abstract individuals (i. e. those with highter cognitive complexity) achieving highter levels of information processing (see Figure 1).

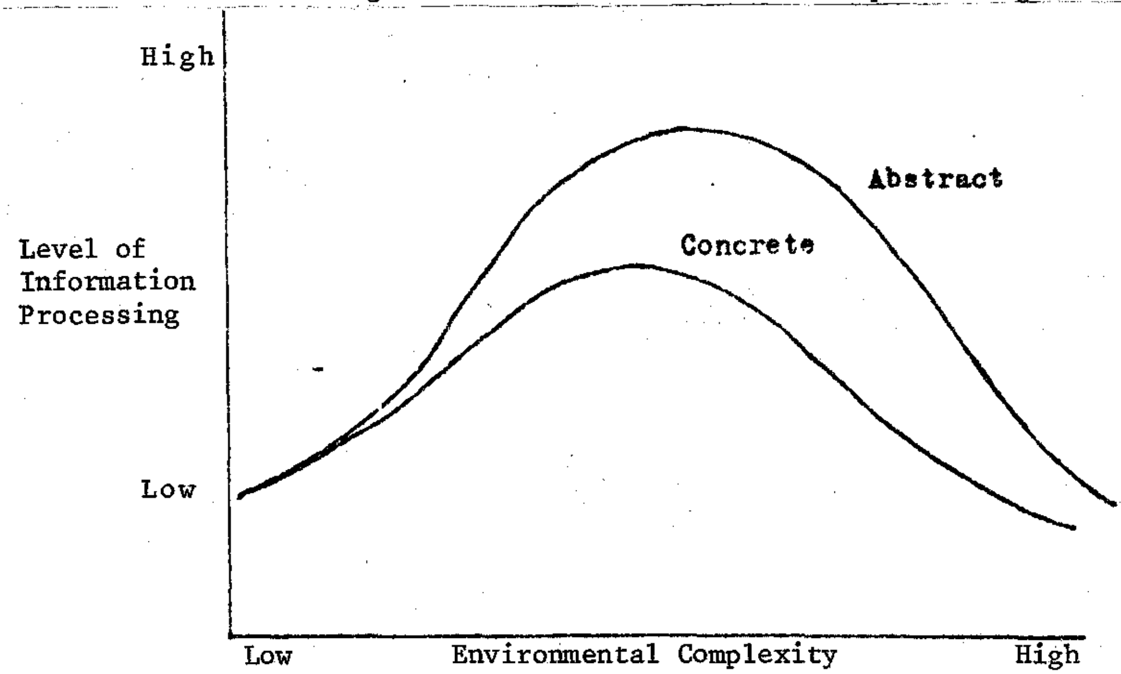

Figure 1
Relationship Between Response and Environmental Complexity for Different Levels of Conceptual Complexity

The major advantage of the cognitive complexity approach is that it articulates both personality and environmental characteristics in order to explain individual behaviour. This feature has motivated accounting researchers to adopt a differential human information processing approach as being most promising for behavioural accounting research (Driver and Mock, [1975]). This study adopts such a differential approach by investigating the combined effects of environmental and personality variables (i.e. level of data aggregation and cognitive style) on decision-making performance. The remaining part of this section considers some alternative personality variables; environmental variables are dealt with in the section on hypotheses formulation.

A variant of the cognitive complexity approach is that of decision style proposed by Driver (Driver and Lintott [1973] and Driver and Mock [1975]). This model is based upon the decision criteria of focus and preference for information rather than upon differentiation and integration. By combining these two dimensions of information processing four main decision styles were identified : Descriptive, Flexible, Hierarchic and Integrative. However, empirical attempts to validate this model have not been successful (Savich [1977], McGhee, Shields and Birnberg [1978]).

The heuristic/analytic model differentiates individuals along a single dimension on the basis of their problem solving approach which covers a continuum of strategies ranging from heuristic (involving an holistic approach, intuition and feelings) to analytic (involving rational analysis of causal relationships). Although the basic concept is appealing, great difficulty has been encountered in constructing reliable measurement instruments (e.g. Huysmans [1970], Vasarhelyi [1973], Barrett et alii [1973] and Barkin [1974]).

The field dependence model uses individual differences in perceptual activities (i.e. ability to overcome embedded contexts) to assess broader dimensions of personal function which cut across diverse psychological areas. Developed by Witkin and his associates over the last thirty years it has been shown (Witkin et alii [1954], Witkin et alii [1962] and Karp [1963]) that the self-consistent behaviour observed is not restricted to perceptual tests, but carries over into a wide range of intellectual tasks. Thus, an individual showing high field independence on perceptual tasks is also likely to perform well at intellectual tasks which require the ability to separate out relevant information from its context (Witkin et alii [1971:18-20]).

Cognitive style models thus appear to tap an important dimension of individual differences that are likely to be relevant to accounting information processing. Although none of the approaches discussed can be regarded as generally superior, each considers decision-making behaviour in a different framework and emphasises different characteristics of human information processing. Indeed the lens and Bayesian approaches have been successfully used in accounting contexts (Barefield [1972], Ashton [1973], Libby [1974], Joyce [1976]). Nevertheless, cognitive style models appear to have important advantages when dealing with realistic decision-making tasks involving complex information. Although they suffer from the disadvantage of not having an optimality criterion built into them this can be overcome by the selection of a decision-making situation with a structure that permits optimisation.

II- HYPOTHESIS FORMULATION

The framework proposed by Dermer [1975] includes as major dimensions the characteristics of the information, the individual, and the task to explain decision-making performance. In this study one variable is selected within each major dimension to enable a simple, yet comprehensive, research design to be constructed.

II.1. Information : Level of Aggregation

It has been intuitively argued that the aggregation level of accounting data will affect decision-makink performance in a curvilinear fashion. The psychological research on cognitive complexity provides some theoretical support for this contention, although individuals having different cognitive complexities may achieve optimum performance at different levels of aggregation, and it is important to control for this.

It is necessary to distinguish between the two types of aggregation. The first one (aggregation type I) affects the amount of data provided without changing the information content of that data with respect to a specific decision whereas the second type of aggregation (aggregation type II) reduces the information content of the data. It should be noted that the distinction between the two types of aggregation is dependent upon the use to which the information will be put. This need to consider the use of the information has been avoided in traditional accounting texts which, based on responsability accounting presentations, make distinction of horizontal, vertical and temporal aggregation.

It is hypothesised that as one moves from highly disaggregated information to more aggregated information decision-making performance will improve, provided that the aggregation is of type I. This view of information overload (Revsine [1970]) has its roots in the cognitive complexity school of human information processing which suggests that, at a certain point, performance decreases with increasing environmental complexity. If the associations between information overload and environmental complexity and between decision-making performance and level of information processing are accepted then the work of Schroder, Driver and Streufert [1967] provides an empirical basis for the above hypothesis. However, in order to provide reliable guidance for the design of accounting information systems it is necessary to conduct a study in an accounting environment.

As the process of aggregation is continued so as to include aggregation of Type II, it is hypothesised that decision-making performance will immediately decline due to the lack of necessary relevant information, as predicted by information economics. Thus, provided a wide enough range of aggregation is considered, decision-making performance is expected to behave as an inverted U-shaped function of aggregation.

There is no accounting research to data which directly suports the above hypothesis, although it is possible to reconcile all previous significant findings with it by assuming that they refer to different parts of the aggregation scale. In order to establish whether it would be possible to experimentally generate the hypothesised curvilinear response, a pilot experiment was conducted in which student subjects at the University of Lancaster were asked to play the role of a production manager and to make production output decisions for a fictitious manufacturing plant. Managerial accounting reports presented at four different levels of aggregation (A1 = non-aggregated; A2 = little aggregated; A3 = moderately aggregated; and A4 = highly aggregated) provided the information on which the production manager could base his decisions. With one exception (A4) all report sets contained sufficient information for making an optimal decision, but they differed on the degree of detail included.

Table 1

Results of Pilot Experiment

Aggregation Level	Frequency of Optimal Decision	Frequency of Non-Optimal Decision	Total	Ratio of Optimal / Total
A1	2	6	8	0.25
A2	6	7	13	0.46
A3	6	3	9	0.67
A4	2	12	14	0.14
Total	16	28	44	

χ^2_3 = 7.50; p = .03 (1-tailed)*

Cramer's V = 0.413

* In this contingency table there are three cells which have an expected frequency of 5 or less and therefore the chi-squared assumptions are not fully met.

The results of the pilot experiment are summarised in Table 1. The null hypothesis that there is no relationship between subject's performance in a production output task and the level of data aggregation is rejected at the 3% level of significance. Furthermore, Cramer's V indicates a strong relationship exists which is cleary shown by the relative frequencies with which optimal production plans were generated by each experimental group. The profile of the relative frequencies has the inverted U-shaped pattern of the hypothesised relationship. Thus, the results of the pilot experiment gave confidence that the hypothesised performance function could be generated experimentally. The task of designing a more refined experimental situation in which the effect of accounting aggregation could be investigated was therefore undertaken. In particular, it was considered important to discover whether the effect of aggregation was permanent or transitory, as much internal accounting information is directed at recurring managerial tasks. Clearly permanent effects are more important than transitory effects in this situation, although both are important in non-repetitive situations. The final experiment therefore incorporated measurement of decision-making performance over a series of similar tasks so that permanent and transitory effects could be distinguished.

II.2. Individual Characteristics : Cognitive Style

It is a commonplace to suggest that different individuals have different information preferences and that perhaps accounting reports should be tailored to match individual requirements, especially since computer technology allows this to be done increasingly economically (Mason and Mitroff [1973]). More formally, psychologists have argued that people of different cognitive styles process the same information in different ways and can be most effective when given different types of information (Goldstein and Blackman [1978]). Although the cognitive style approach is only one of many psychological models it possesses both an inherent plausibility and some evidence of successful application in accounting research (Libby and Lewis [1977]). For example, accounting studies have reported that high-analytic individuals prefer information with a different format and content to that preferred by low-analytic individuals (Huysmans [1970], Doktor and Hamilton [1973] and Lusk [1973]).

Of the wide variety of cognitive style models available, the field dependent/independent model was selected because it has been extensively investigated by psychologists and a great deal of effort has been devoted to establishing reliable methods of measurement. In addition, previous use of the model in accounting research on human information processing will allow results to be compared. The instrument used to measure cognitive styles is the Group Embedded Figures Test (GEFT), which is an adaptation of the original individual EFT enabling group testing to be undertaken. It is straight-forward to administer and score and there is evidence of its reliability and validity (Witkin et alii [1971], Goldstein and Blackman [1978]).

Field dependence is not a characteristic that affects performance across all tasks. Rather, individuals who are field independent or have an 'analytical field approach' (Witkin et alii [1971]) have a style of problem-solving activity which involves a ready ability to overcome an embedding context and to experience items as discrete from the field in which they are contained. Field dependent individuals, on the other hand, have a 'global field approach' which involves a submission to the dominant organisation of the field and tend to experience items in an holistic manner, fused with their background. Thus, performance on particular tasks will vary depending upon which of these abilities is most relevant.

The experimental tasks involved in this study are essentially parts of a cost behaviour analysis. By suitable analysis it is possible to model the operations of the simulated production plant and to make accurate estimates of future costs. However, the management accounting reports provided as an information source are not designed for this specific purpose, and do not explicitly disclose the relationships that underly plant performance. The process of modelling plant operations therefore demands the ability to extract information and use it in a different context (i.e. a disembedding ability). It is therefore expected that field independent individuals will perform better on these tasks than those who are more field dependent.

II.3. Tasks : Degree of Complexity

There are many task characteristics that are believed to influence a decision-maker's effectiveness such as the degree of uncertainty in the task, its complexity and the amount of involvement it generates in the decision-maker. In this research just one aspect of the task is examined, namely its structural complexity, as it is thought that this would give some insight into information processing behaviour without confounding other experimental conditions. Two broadly similar experimental tasks were designed, namely the estimation of marginal contributions to profit of each of two products and the estimation of total contribution to profit of the overall production plan. The tasks differ in their structural complexity for although both tasks demand the same basic skill (i.e. the ability to perform a cost behaviour analysis), to achieve a given level of accuracy requires a more sophisticated model for the first task than for the second. In other words, the estimation of contribution to profit is more tolerant to model errors than the estimation of marginal contribution. Thus, good performance on the more complex task indicates a higher level of information processing than similar performance on the simpler task.

II.4. Hypotheses

The following formal hypotheses have thus been derived. These are stated in a positive form whenever there are plausible theoretical reasons for a given relationship between variables, otherwise the null form is stated:

H1: As the level of aggregation of the accounting information is increased, performance on both tasks will first increase and then decrease; decision time will first decrease and then increase, but no difference will occur in the rates of learning.

H2: Field independent subjects will perform better than field dependent subjects on both tasks; there will be no difference in decision time and learning rate for the two groups.

H3: Decision-making performance will be better on the less complex task than on the more complex task. Field independent subjects will outperform field dependent subjects by a greater margin on the more complex task.

III- METHODOLOGY

An experimental setting was considered most appropriate for testing the foregoing hypotheses as it allows the researcher to manipulate some variables of interest whilst controlling others. In this case it is necessary to ensure that a wide range of variation in the aggregation level of the accounting reports is available, so that conditions ranging from lack of relevant information to information overload are simulated, whilst controlling for environmental differences. A production simulation game (PROPLAN) was therefore devised which incorporated the necessary features.[5]

The underlying structure of the PROPLAN game was a linear programming formulation of a manufacturing plant making two products (A and B) utilising five internal processes. Resources are limited primarily in terms of the labour hours available although a certain amount of overtime may be worked if premium rates are paid. The task facing the subject acting as the PROPLAN plant manager is to devise a production plan which maximises the plant's contribution to profit in each of a sequence of periods. In order to aid the manager in this task, internal accounting reports of a traditional type are provide, although the amount of detail contained in the reports is manipulated as an experimental variable. The production mix problem has been well studied, so a normative decision model can be formulated that generates an optimal solution. As the information requirements of the model can be precisely specified, aggregation of type I can be distinguished from aggregation of type II in the accounting reports.

Finally, subjects were provided with a normative model to convert basic decision inputs (estimates of marginal costs) into an appropriate production plan (quantities of each product to be made), in the form of linear programming algorithm on a Commodore PET 2001 desk computer. On receipt of the production plan, subjects then estimated the total contribution to profit expected for the period. Use of this model confined the experimental task to the estimation of decision inputs and overall contribution whilst enabling feedback to be given on outcomes, thus eliminating the variability that would be introduced by differences in individuals' own models of how a production plan should be derived from cost and price information.

It may appear that the experimental task is mechanical and over-simple, but it is not. The relationships between decision variables (overtime hours, production levels, product mix, etc.), and the final outcomes (revenues, production costs, etc.) are not explicitly stated, nor can they be derived from a single set of reports. The real experimental task is not to determine an optimal production plan, but rather to develop an understanding of the underlying relationships between the decision variables and the eventual outcome. Subjects are given results relating to two periods at the start of the experiment; in each of the five subsequent experimental trials they specify their decision inputs, have these converted into a production plan, estimate its total contribution and are then given a copy of the accounting report that results from the operation of the selected production plan.

Other important characteristics of the PROPLAN simulation are that it is non-competitive, non-interactive and deterministic. As it is non-competitive the behaviour of any particular participant does not affect the situation facing the others and subject responses are therefore independent. By being non-interactive, the subject does not alter the sequence of experimental conditions assigned to him, although he does receive feedback concerning the outcomes of his previous decisions. Finally, the deterministic nature of the situation avoids unnecessary variations in outcomes due to chance. Individual subjects are thus observed in a sequence of independent trials that differ only in the learning about the underlying situation carried by the subject from one trial to the next.

Subjects were drawn from students in the School of Management and Organisational Sciences at the University of Lancaster who volunteered following an oral presentation about the nature and general purpose of the experiment, although aggregation was not specifically mentioned. All subjects had studied sufficient accounting to be familiar with the type of report presented in the experiment. As the experiment demanded about four hours of their time a financial inducement was offered which comprises £2 for completing the task plus an extra £1 if the subject's performance was above average. Twelve subjects were used as a pre-test of the experiment and a further 48 for the main experiment, of whom 40 completed all five trials.

Each subject was tested for cognitive style (using the GEFT) and then randomly assigned to an experimental treatment, subject only to an overall spread being maintained such that each aggregation level was assigned to students of all levels of cognitive complexity. An individual subject was given accounting reports at the same level of aggregation in all five trials, as it was considered that the order of receiving reports of different aggregation levels might affect performance. The experimental design is thus a nested factorial design (also known as a factorial experiment with repeated measures). This design is an extension of the one-factor repeated measures design, where subjects are observed under all levels of some, but not all factors. In this case all subjects were observed in each of the five periods of play, but represented only one combination of factors measuring aggregation level and cognitive complexity.

III.1- Measurement of Variables

The independent variables in this study are level of aggregation, cognitive complexity and degree of task complexity. Aggregation level was manipulated by assigning reports to subjects at one of four levels of aggregation. Of these, one (A4) contained insufficient relevant information and thus represented aggregation or type II; the remainder contained increasing comments of detail and represented aggregations of type I. The cognitive complexity of subjects as measured by the GEFT was used to match subjects to reports in a uniform manner. Subjects with scores below the median were defined as field dependent; those with higher scores as field independent. Each subject was asked to complete two tasks, namely to estimate the marginal contribution generated by each of the two products and also to estimate the contribution to profit of the overall production plan. Task performance was measured in the following ways:

i) Decision inputs estimation performance

The estimation of decision inputs (i.e. the marginal contributions to profit of products A and B) is one of the two main experimental tasks. The accuracy of these estimates reflects the subject's understanding and processing of the information provided to him. A straightforward measurement of percentage error in the estimate was used initially, defined as:

$$DIEE_{ij} = 100 \times \frac{1}{2} \sum_{k=1}^{2} \frac{|AVC_{ik} - EVC_{ijk}|}{AVC_{ik}}$$

where: $DIEE_{ij}$ is the decision input estimation error for period i and subject j;

AVC_{ik} is the actual variable cost for product K; and

EVC_{ijk} is the estimate made for product K by subject j in period i.

However, this proved to have a deficiency in that some apparent functional fixation in subjects' behaviour was noted. The accounting reports provided contained two levels of cost aggregation, namely total direct cost and total production cost for each product. Neither of these, in fact, represented the variable cost of production, but subjects showed an inclination to take one or other figure as a surrogate for the true variable cost, which lay between the two. As the true variable cost was different from trial to trial, and as both direct cost and production costs were considered equally incorrect as estimates of it, a more complex measure of decision input estimation performance was defined as follows:

$$DIEP_{ij} = 100 \left[1 - \frac{1}{2} \sum_{K=1}^{2} RD_{ijk} \right]$$

where: $DIEP_{ij}$ is the decision input estimation performance for period i and subject j and

RD_{ijk} is the relative displacement of the decision input defined as:

$$RD_{ijk} = \begin{cases} \left| \dfrac{AVC_{ik} - EVC_{ijk}}{AVC_{ik} - PC_{ik}} \right| & \text{if } EVC_{ijk} > AVC_{ik} \\[2ex] \left| \dfrac{AVC_{ik} - EVC_{ijk}}{AVC_{ik} - DC_{ik}} \right| & \text{if } EVC_{ijk} < AVC_{ik} \end{cases}$$

where: PC_{ik} is the production cost per unit for product k in period i;

DC_{ik} is the direct cost per unit for product k in period i; and

AVC_{ik} and EVC_{ijk} defined as above.

The result of this transformation is represented in Figure 2. Thus totally accurate estimation will lead to DIEP being 100; functional fixation on either item in the accounting statement will yield a value of zero. In fact, both measures of decision input performance were found to give very similar results with respect to aggregation level.

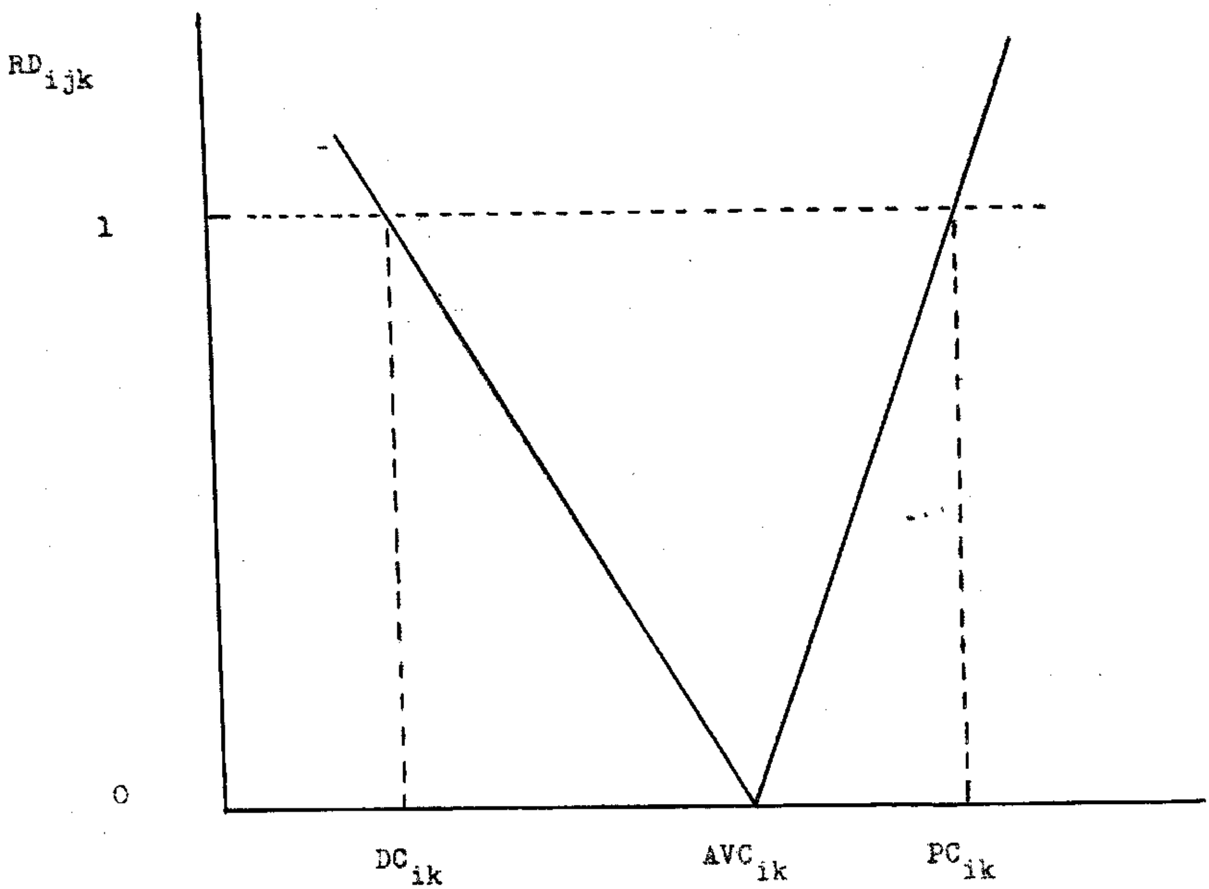

Figure 2

Transformation of Decision Input Estimation Error into Relative Displacement

ii) Contribution to profit estimation performance

The second main experimental task is to estimate the total contribution to profit made by the chosen production plan. Performance was again measured by the percentage error in the estimate:

$$CPEE_{ij} = 100 \left| \frac{ECP_{ij} - ACP_{ij}}{ACP_{ij}} \right|$$

where: $CPEE_{ij}$ is the percentage error in contribution to profit estimation for period i and subject j;

ECP_{ij} is the subject's estimate of contribution to profit; and

ACP_{ij} is the actual contribution to profit attained.

However, it was found on analysis that the variance of this measure was not the same for all treatment groups, the standard deviation being proportional to the mean. In order to overcome this problem, and to transform the variable into one that met the conditions for analysis of variance, a logarithmic transformation was used (Kempthorne [1967]) and a performance criterion defined as:[6]

$$CPEP_{ij} = K - \ln (|ECP_{ij} - ACP_{ij}| + 1)$$

where $CPEP_{ij}$ is the contribution to profit estimation performance of subject j in period i, and has a maximum value of K for completely accurate estimation.

iii) Decision time performance

No time constraints were placed upon subjects in making their estimates. The actual time spent on each trial was recorded and is used as measure of perceived task difficulty. The recorded decision times (DT) showed a lack of homogeneity to variance, with the variance of each treatment group being proportional to the means. To make this variable suitable for analysis of variance a square root transformation is appropriate (Kempthorne [1967]) and decision time performance (DTP) defined as:

$$DTP_{ij} = K - \sqrt{(DT_{ij})}$$

where the constant K is introduced purely to shift the origin, giving DTP a maximum value of K.

IV- RESULTS

Two major types of analysis are performed on the data gathered from the 40 subjects who successfully completed all five trials in the experiment.[7] Analysis of variance is used to test which of the main experimental factors (level of aggregation, cognitive style and period of play) have a statistically significant effect on task performance; trend analysis is used to test whether the effect of aggregation can best be summarised by either a linear or quadratic trend and also whether there is a significant learning effect over the duration of the experiment. Only effects which are statistically significant on these tests are explored further. The transformed variables are used in the analysis of variance to ensure statistical validity and are presented in the Figures; the non-transformed variables are more appropriate for interpretation and are presented in this Tables.

IV-1. The Effect of Aggregation Level

Aggregation level is found to affect the two major performance variables. Decision input estimation performance (DIEP) is strongly influenced by aggregation level (p= .01) whereas contribution to profit estimation performance is less significantly affected (p= .15); decision time shows only a marginally significant effect (p= .25) as shown in Tables A.1, A.3 and A.5, respectively. Further the relationship between aggregation level and DIEP and CPEP is found to be best fitted by a quadratic rather than a linear function (Tables A.2 and A.4). These results and presented diagramatically in Figure 3 which shows that the general pattern is in accordance with the hypothesis. That is, performance improves as the accounting reports become more aggregate until information loss occurs and performance then begins to deteriorate.

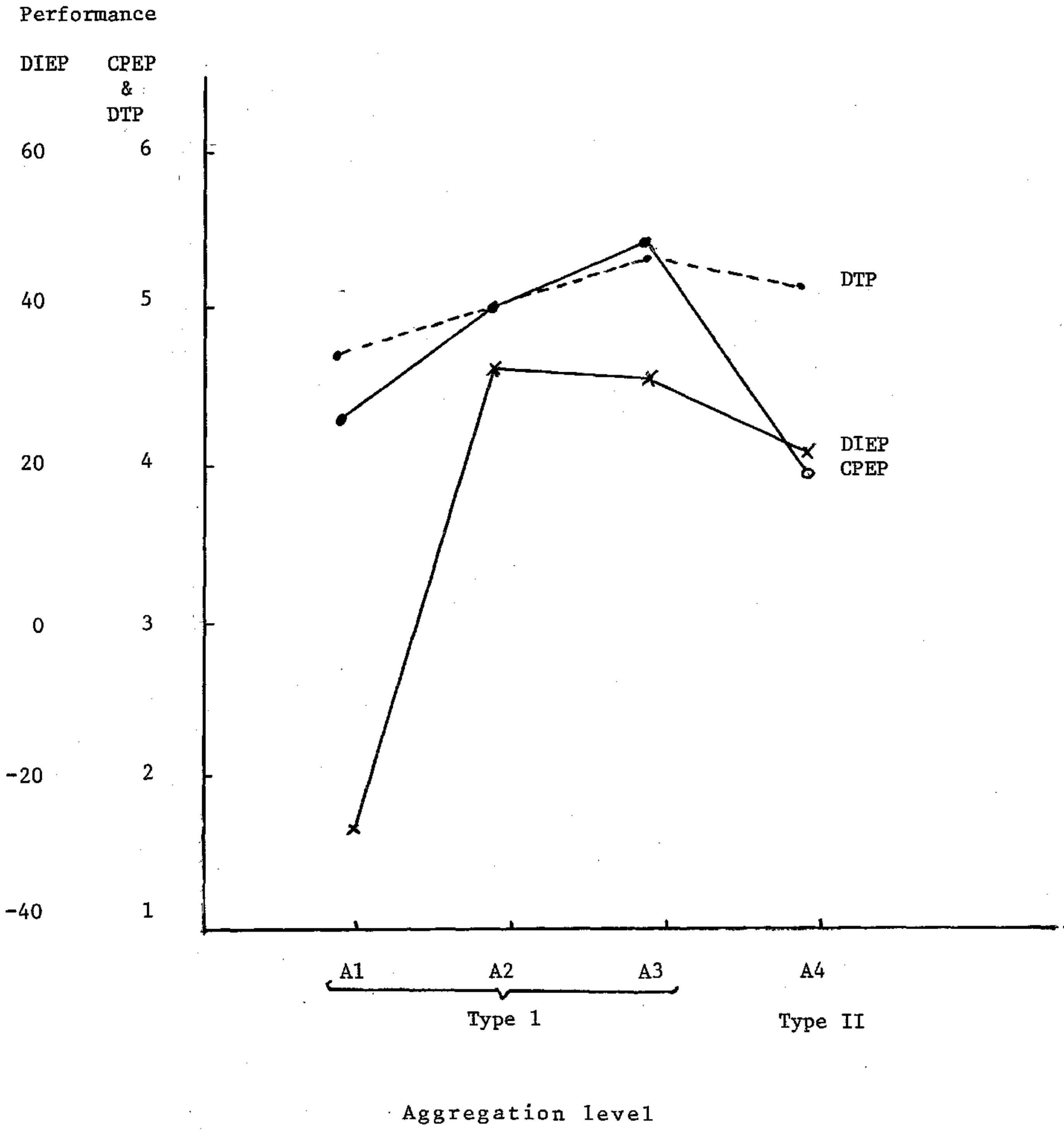

Figure 3

Decision-Making Performance by Aggregation Level

Further insight may be obtained by observing the basic performance variables of decision input estimation error (DIEE), contribution to profit estimation error (CPEE) and decision time (DT) which, although not suitable for analysis of variance, give a clearer picture of actual performance. These are summarised in Table 2, and fuller details given in Tables A.7, A.8 and A.9. It can be seen that the optimum result on both tasks and also the shortest decision time occurs with the

Table 2

Effect of Aggregation Level on Performance

	Aggregation Level A1	A2	A3	A4	∝
DIEE	36.1	22.6	21.5	24.2	1v2 p = .02
					1v3 p = .015
					1v4 p = .02
CPEE	7.7	10.1	3.6	10.9	1v3 p = .11
					2v3 p = .07
					3v2 p = .025
DT	33.1	29.5	24.8	27.0	1v3 p = .03
					1v4 p = .08
					2v3 p = .02
					3v4 p = .10

most aggregate report containing full information (A3), thus fully supporting hypothesis 1.

In addition, the group which received the highly disaggregated reports (AG1) showed an average performance as poor as (for the dependent variable CPEE) or even poorer than (for the dependent variable DIEE) the group which received the overaggregated reports (AG4). That is, information overload can be as bad as or even worse than lack of relevant information. Such as situation was also observed for the decision time variable, which was markedly greater when disaggregated information was supplied. Thus, contrary to the assumptions of information economics, the value of disaggregated information appears to be substantially less than the value of more aggregate information, even when aggregation reduces the information content of the accounting report.

Despite the similarities in the profiles of performance on both the major estimation tasks, the individual performance measures (DIEP and CPEP) are not correlated (r=.04), indicating that the tasks required different abilities of the subjects. It is noteworthy that the aggregation level of the accounting reports affects performance on both tasks in a similar way and it may be concluded that aggregation level is an important variable for a variety of tasks.

It was finally suggested that learning would not be affected by aggregation level. Any such effect will be picked up by the interaction between aggregation level and period of play. This was found to be significant for DIEP (p=.01) and DTP (p=.14). However, the results for DIEP showed no consistent patterns over periods and the interaction effect cannot be interpreted as learning except for the optimum accounting report (AG3) which showed a steady improvement over periods. Similarly, this report gave the most rapid improvement in performance on CPEP, perhaps indicating that the most important advantage of optimum information is effective learning.

The relationship between decision time performance and aggregation level over periods showed a clear relationship with the most rapid reduction in decision time occuring with the disaggregated reports (A1 and A2) and the slowest reduction with the agrregated reports (A3 and A4). Nevertheless, the time taken to make decisions in the final period is similar for all groups and indicates that familiarity with the reports causes any initial differences in decision time due to aggregation level to be minimised.

Hypothesis 1 is thus substantiated with the expected inverted U-shaped performance functions being found for all dependent variables. Speed of learning is however found to be associated with aggregation level mainly because disaggregated information causes initial decisions to take a longer time whereas experience in using reports reduces such differences. Human information processing approaches thus provide a framework for explaining these observations in a way that information economics does not.

IV-2. The Effect of Cognitive Style

Cognitive style was found to have no significant effect on decision-making performance at either task, as indicated in Tables A.1 and A.3. Whilst field independent subjects slightly outperformed their field dependent colleagues in estimating contribution to profit, the reverse was true in estimating decision input. Decision time was also unaffected by cognitive style. Although the interaction between cognitive style and period showed up as significant on CPEP (p=.13) and DTP (p=.07) there is no evidence to suggest that this represent a difference in learning patterns between subjects of different cognitive styles.

Individual differences, as measured by cognitive style, do not therefore account for any of the observed differences in decision-making performance or learning. However, it is of note that the subjects do not represent a typical sample from the population at large, as they tend to be highly field independent.

If Witkin's [1971] study is accepted as defining the distribution of GEFT scores in the population then only 7 of the 40 subjects scored less than the population average of 12, and may thus be truly described as field dependent. An analysis of variance conducted on the basis of this split indicated that cognitive style affected CPEP (p=.15), with field independent subjects performing better than field dependent subjects. Nevertheless, it can only be concluded from these results that cognitive style does not affect decision-making performance on this experimental tasks in the manner expected; rather, it is found to have few significant effects. This null result is similar to that found in other accounting studies using cognitive complexity as an explanatory variable, indicating that there are still considerable problems remaining in transferring these psychological concepts into the accounting arena.

IV-3. The Effect of Task Complexity

It is hypothesised that task complexity will affect decision-making performance and it is argued that the estimation of overall contribution to profit is a less complex task than the estimation of the marginal contribution to profit of each product. However, as absolute comparison of performance on the two tasks is not possible for the very reason that they are dissimilar. Nevertheless, the percentage errors made in estimation on the two tasks may be compared, which although not a perfect means of comparison-allows general differences to be noted. These are shown, period by period, in Table 3.

Table 3
Percentage Errors in Estimation on Two Tasks

Task	Period					Overall
	1	2	3	4	5	
DIEE	27.1	24.0	24.7	28.3	26.3	26.1
CPEE	17.8	7.0	7.7	5.6	2.3	8.1
α	p=.06	p<.001	p<.001	p<.001	p<.001	p<.001

These results make it quite clear that a much greater accuracy was attained in estimating contribution to profit than in estimating the marginal contributions of the two products, the overall difference being highly significant ($p < .001$). In addition, the CPEE tended to get smaller period by period whereas no such learning effect was noted for DIEE. However, it is probable that this latter effect is due more to differences in feedback information than to task complexity. When a previous period accounting report was received the subject was able to make a direct comparison between his estimate contribution to profit and the actual contribution attained. Although actual cost figures for the marginal contributions of each product are contained in the report it is necessary to select the appropriate sub-headings and aggregate them. A subject with an incorrect decision model would therefore receive no direct indication of how he was in error. Thus, although the initial difference in estimate errors (which shows a significant difference ($p = .05$)) may indicate the effect of task complexity, subsequent differences are confounded by the effect of different types of feedback information.

It was also hypothesised that field independent subjects would outperform field dependent subjects on both tasks, but by a greater margin on the more complex task. The results shown in Table 4 do not confirm this hypothesis.

Table 4

Task Performance by Cognitive Style

Task	Cognitive Style		α	Cognitive Style		α
	FI	FD		FI'	DP'	
N	20	20		33	7	
DIEE	29.3	22.9	$p = .06$	26.7	23.2	NS
CPEE	7.9	8.2	NS	7.6	10.5	NS
DT	29.2	28.0	NS	29.2	25.8	$p = .15$

FI: Field independent GEFT $\geqslant$ 16
FD: Field dependent GEFT < 16
FI': Field independent GEFT $\geqslant$ 13
FD': Field dependent GEFT < 13

The only significant results indicate that field dependent subjects do better than field independent, although when Witkin's split is used task differences are no longer significant. Thus, cognitive style does not feature as a useful factor in explaining differences in task performance.

IV-4. Effect of Period of Play : Learning

Period of play is not a true experimental factor, but it is an important explanatory factor. Repeated measurement of performance on similar but independent tasks permits comparisons to be made in the search for learning patterns. It must be emphasised that although the experimental design ensures that any trends must reflect subject-related factors, learning is not the only possible factor operating. For example, fatigue and changes in motivation due to prior trials, perhaps caused by frustration, will be included. Nevertheless, given the tightly controlled experimental conditions, it is likely that learning is the most likely cause of any improvement in performance over trials.

It is found that period of play has a significant effect on CPEP (p=.01) and DTP (p=.01) although it has little effect on DIEP (p=.25). There was evidence of a linear trend for both CPEP (p=.01) and DTP (p=.01), but not for DIEP, as can be clearly seen in Figure 4, and by examination of Table A.7.

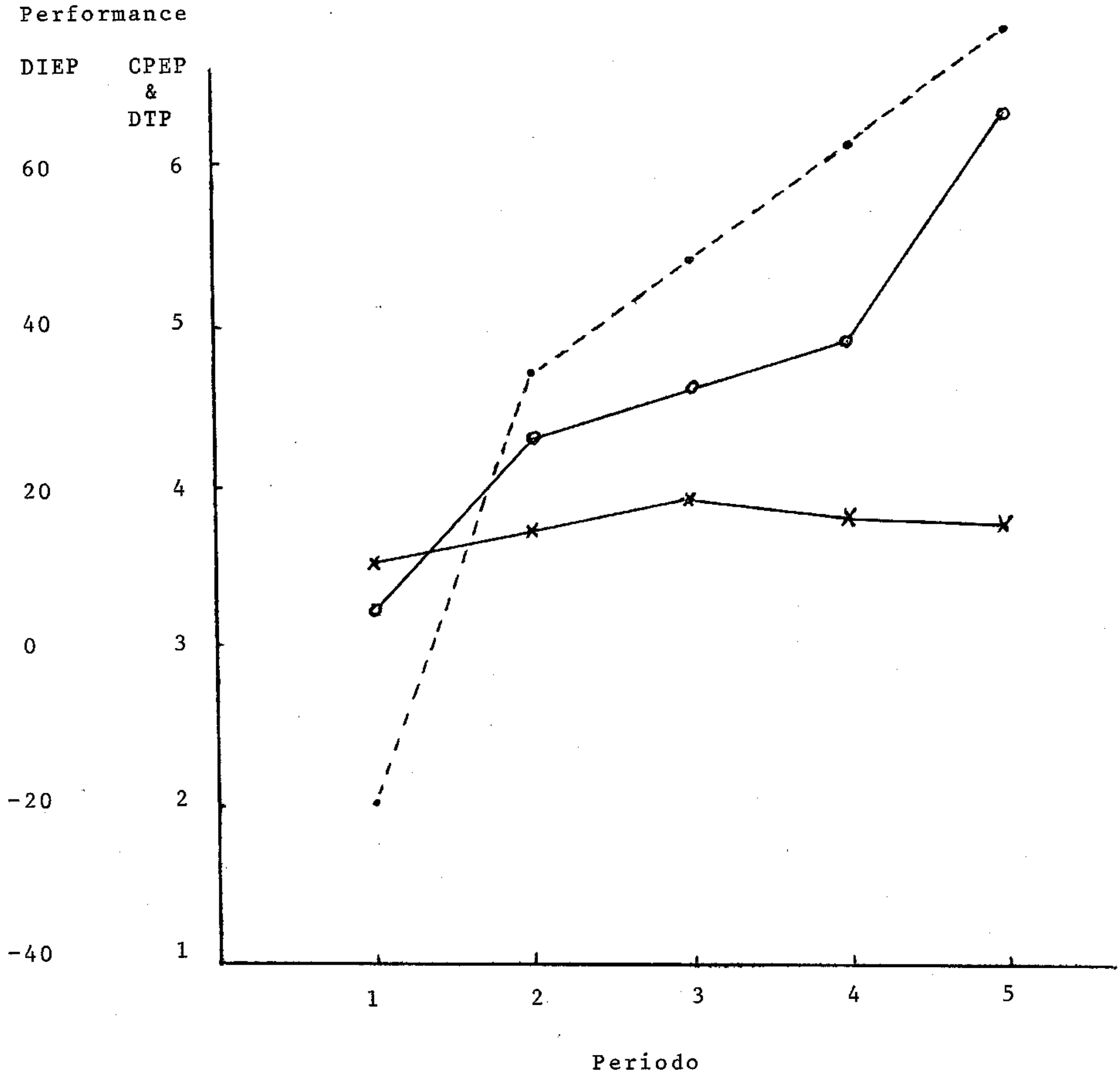

Figure 4

Decision-Making Performance by Period

These statistically significant factors can also be seen in the straightforward versions of the performance measures shown in Tables 2 and 4. Experience of the tasks causes a rapid drop in decision time, and the accuracy of contribution to profit estimates also improves markedly, although the accuracy of decision input estimation ramains more or less constant. This difference in learning pattern is associated with the provision of easily assimilated feedback information. In the case of contribution to profit the learning process is subject to immediate and accurate feedback of actual results whereas the marginal contribution required by the decision input estimation task had to be calculated from the accounting reports.

Aggregation level is also relevant to learning. The more aggregated reports required less time to assimilate and to make decisions; however, when information was lost decision time increased again. From a relatively poor start in the first period CPEP improved more rapidly for the optimum accounting report (AG3) than for the other types, but the final level of performance was similar for all report groups. On decision input estimation all reports gave significantly better performance than the highly disaggregated report. There is thus some evidence that experience of using accounting reports and learning from the feedback of information on actual performance may reduce the effect of accounting aggregation on some tasks, but where feedback is absent or the task is complex, aggregation has a more permanent effect.

V- DISCUSSION

The results of the tests of the main experimental hypothesis are summarised in Table 5. It can be seen that whereas the experiment generally confirmed the prior expectations concerning the effect of aggregation level and task complexity, it yielded surprising results for cognitive complexity, although these are of low statistical significant. Nevertheless, it indicates the need for a more thorough consideration of the effect of individual differences in decision-making tasks.

The major experimental hypothesis that data aggregation will affect decision-making performance in a curvilinear fashion is adequately confirmed. The provision of an excess of irrelevant data caused task performance to deteriorate in an alarming manner. For example, in comparison with the performance attained using AG3- the most aggregated report containing all the necessary information — excess information more than doubled the 3 1/2% estimation error on the simpler task, and increased the 22% estimation error on the more complex task by more than half. On the more complex task it was also found that excess information had a more adverse effect than the provision of insufficient information. Further, not only did the provision of excess information increase estimation errors, but it also caused a significant increase in decision time in all but the final period of the experiment. That is, subjects provided with disaggregated information took longer to make decisions of substantially inferior quality than those provided with more aggregated information.

In addition, although the effect of differences in type of aggregation reduced period by period for the simpler task, no such reduction was apparent for the more complex task. Despite this effect being confounded by the simpler task which also has a more direct feedback on results, it is evident that the effect of aggregation is conditioned by the type of task undertaken. Although the curvilinear performance function may be only transitory on simple tasks where rapid and appropriate feedback on performance is available, it is likely to be more permanent on complex tasks having less direct feedback. The more important and less routine business decision-making tasks are thus more likely to be affected by aggregation than the more routine tasks.

The most disaggregated report used in this experiment was not of great length, comprising just seven sheets of well-tabulated computer printout. It was loosely based on real manufacturing cost reports used by some U.K. companies and represents a concise general purpose accounting report. Indeed, by the standards of many companies, the most disaggregated report used would be considered to be a succinct and apt document. If such a report can produce the effects noted here, it is likely that the use of highly disaggregated reports will produce substantial effects in practice. The evidence of this study strongly suggests that the level of aggregation of an accounting report has an important influence on decision-making performance.

Individual differences in cognitive complexity had few significant effects in this experiment, contrary to prior expectations. Although this may be, in part, explained by the clustering of the sample at the field independent end of the discussion, it is nevertheless clear that differences in field dependence do not help to explain the observed differences in performance. The effects of data aggregation, task complexity and experience at the task all show their expected effects across relatively small samples of individuals and regardless of individual differences. From this point of view, one deficiency of the experiment is that it does not explore the effect of aggregation on each individual (mainly because to control for the order of presentation would have required a much larger sample) but relies on random allocation of individuals to each aggregation condition. The pattern of individual responses suggests that different people may well process information in different ways and that an optimal presentation for one person may be less than optimal for another. This suggestion however requires substantial further investigation for confirmation;

what is significant from this study is that despite such possible differences, marked patterns of effects independent of such differences were observed. The provider of accounting reports is probably justified in regarding individual differences as secondary to major factors such as aggregation level, task complexity and experience.

Task complexity was found to have a marked effect on decision-making performance, although it should be noted that the two experimental tasks differed in several ways. The estimation of the contribution to profit of a selected production plan was regarded as a relatively simple task. Even if a crude predictive model was used, the provision of timely and direct feedback information helped ensure that a high degree of accuracy could be attained. On the other hand, the estimation of the marginal contribution of each product required an appropriate model to be developed. A number of subjects developed a form of functional fixation by (incorrectly) interpreting a particular sub-heading on the accounting report as the marginal cost of the product. Given this assumption the feedback information they received would confirm they had accurately estimated the sub-total (although not the correct marginal cost); a non-optimal production plan would be implemented, but this was not immediately obvious as the true optimal plan was not known. As might be expected in these circumstances, learning occurred at a much slower rate, if at all. But, in addition, it was found that the provision of highly disaggregated data produced a deterioration in performance on this task considerably more marked than that produced by not supplying relevant information. Thus, in the conditions likely to surround many real-life business decisions (i.e. high task complexity, poor feedback information and lack of knowledge of optimal opportunities) the provision of disaggregated information produces significantly poorer performance. The design of accounting reports that provide precisely relevant information for particular decisions is therefore of paramount importance.

The findings of this study are subject to a number of limitations. Firstly, it is a laboratory study conducted under artificial circumstances and using student subjects. This was necessary in order to attain sufficient control for causality to be inferred. Although the use of student subjects is acknowledged to be a controversial issue in accounting research (Abdel-Khalik [1974b]), it is by no means evident that external validity would increase if managerial subjects were used in the same conditions (Alpert, [1967]), as students playing a business game may take their role more seriously than managers in a game situation. Secondly, the simulated environment was accessible only through accounting reports and compressed monthly periods into a few hours. Real-life managers would gain greater experience over a much longer period. Thirdly, the experiment was a tiring and rather pressured situation, particularly for those subjects given the disaggregated reports. Subjects had little time to develop an understanding of the underlying relationships, and this could lead to considerable frustration. It is perhaps significant that half the subjects who gave up before completing all five trials were those allocated to the non-aggregated (A1) group. Finally, the conclusions apply only to well specified tasks where an optimal information requirement can be determined. The problem of information requirements in an illstructured, little understood or uncertain situation has not been tackled here. The findings of the study must therefore be regarded as indications as to what may be expected in certain real-life situations; given the results reported here it would seem desirable to confirm the effects in field observation studies, despite the loss of internal validity that would be entailed. Nevertheless, sufficient evidence has been obtained to indicate that it is an important area for study.

VI- SUMMARY AND CONCLUSIONS

This research was undertaken to establish whether the suggested curvilinear relationship between data aggregation and decision-making performance could be established. Previous work in an accounting context, although suggesting such a relationship, had failed to generate conclusive results. This study clearly demonstrates that aggregation level affects performance in the hypothesised manner on two different, independent decision-making tasks. Moreover, the time taken to make decisions was also affected in a similar way.

These results are consistent with those reported by Chervany and Dickson [1971] and by Tiessen [1976]. Chervany and Dickson found that subjects who received statistically summarised data showed a better production cost performance than those who received raw, more detailed data. Similarly, Tiessen found that for one product in particular, production costs decreased as reports became more aggregated. Overall the findings suggest that data reduction by means of aggregation type I improves decision-making performance; further aggregation of type II then causes it to deteriorate. Although the effect of aggregation may be only transitory, and disappear with experience on some tasks, it is likely to be more permanent on others. Where rapid feedback on performance is available, crude decision models may prove adequate, but where more complex modelling is required aggregation is likely to be an important variable. The designer of a management information system should therefore attempt to avoid the supply of redundant and irrelevant information (e.g. cost allocation), even to the extent of sometimes not supplying relevant information. This care is particularly necessary when the decision-making task requires complex modelling and where feedback on results is lacking.

Individual differences in cognitive complexity were found to have little effect. Indeed, to date, studies in accounting have not succeeded in establishing relationships between cognitive complexity and individual information processing characteristics.

This may be due, in part, to an inappropriate choice of concept and it seems advisable that further knowledge should be sought about the importance of individual differences on information processing. For the present it would appear most fruitful for the information system designer to concentrate upon mataching the information content of accounting reports with the type of task being undertaken, rather than in attempting to provide information matched to individual characteristics.

./sspm.

FOOTNOTES

(1) San Miguel [1976] investigated a U-curve, but using a different independent variable, namely uncertainty of information. Schroeder and Benbasat [1975] also explored the relationship between uncertainty in a decision-making environment and the desirable characteristics of management information.

(2) Some previous work has been criticised on these grounds. See, for example, Oliver's discussion of Abdel-Khalik [1973].

(3) For some examples of how organisational factors can affect the transmission of information across different levels of the organisational hierarchy see Read [1962], Athanassiades]1973[, and Berry and Otley [1975].

(4) For a more comprehensive review of this area see Libby and Lewis [1977] and AAA [1978].

(5) A full description of the experimental material is available in Dias [1979].

(6) Absolute error is used rather than percentage error as ACP changes very little; the addition of 1 to the modules of the estimation error is introduced to avoid an argument of zero in the logarithmic function and the constant K merely shifts the origin to give positive values of the performance measure.

(7) Of the eight subjects who dropped out before completing five trials, four had been seen assigned to the non-aggregate group (A1) and two to each of other type I aggregation groups (A2 and A3). They showed no predominant cognitive trait.

APPENDIX

ANALYSIS OF VARIANCE, TREND ANALYSIS AND SUMMARY TABLES

TABLE A. 1

Analysis of Variance Summary
Decision Inputs Estimation Performance

Source of Valuation	Sum of Squares	Degrees of Freedom	Mean Square	F	α
Within subjects	4.916	160	.031	-	-
period	.154	4	.308	1.46	25%
period x aggregation	.737	12	.061	2.35	1%
period x style	.026	4	.006	.23	ns
three way interaction	.639	12	.053	2.04	3%
error within	3.365	128	.026	-	-
Between subjects	38.062	39	.976	-	-
aggregation	11.550	3	3.850	5.83	1%
style	1.103	1	1.103	1.67	25%
aggregation x style	4.290	3	1.430	2.17	11%
error between	21.119	32	.660	-	-
Total	42.978	199	.216	-	-

Appendix (Cont.)

TABLE A. 2

Trend Analysis Summary
Decision Inputs Estimation Performance

A- Linear Trend Analysis for Period of Play

Source of Valuation	Sum of Squares	Degrees of Freedom	Mean Square	F	∝
Within subjects	2.3641	40	.0591	-	-
linear trend	.0657	1	.0657	1.35	ns
period x aggregation	.2863	3	.0954	1.96	19%
period x style	.0045	1	.0045	.09	ns
three-way interaction	.4464	3	.1488	3.05	4%
Residual	1.5612	32	.0488	-	-

B- Linear and Quadratic Trend Analysis for Aggregation level

Source of Valuation	Sum of Squares	Degrees of Freedom	Mean Square	F	∝
Aggregation					
linear	4.927	1	4.927	7.46	2%
quadratic	5.962	1	5.962	9.03	1%
Aggregation x style					
differences in linear	.158	1	.158	.24	ns
differences in quadratic	4.036	1	4.036	6.12	2%
Residual	21.119	32	.660	-	-

Appendix (Cont.)

TABLE A. 3

Analysis of Variance Summary
Contribution to Profit Estimation Performance

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	∝
Within subjects	1021.825	160	6.386		
period	208.245	4	52.061	10.19	1%
period x aggregation	76.374	12	6.365	1.25	ns
period x style	38.112	4	9.528	1.86	13%
three-way interaction	44.897	12	3.741	.73	ns
error within	659.197	128	5.111	-	-
Between subjects	588.817	39	15.098	-	-
aggregation	73.208	3	24.403	1.89	15%
style	14.105	1	14.105	1.09	ns
aggregation x style	87.236	3	29.079	2.25	11%
error between	414.268	32	12.946	-	-
Total	1610.641	199	8.099	-	-

Appendix (Cont.)

TABLE A. 4

Trend Analysis Summary
Contribution to Profit Estimation Performance

A- Linear Trend Analysis for Period of Play

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	∝
Within subjects	473.2956	40	11.8324	-	
linear trend	195.5858	1	195.5858	24.43	1%
period x aggregation	9.1807	3	3.0602	.38	ns
period x style	2.5993	1	2.5993	.32	ns
three-way interaction	9.7280	3	3.2427	.40	ns
Residual	256.2018	32	8.0063	-	-

B- Linear & Quadratic Trend Analysis for Aggregation Level

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	∝
Aggregation					
linear	2.088	1	2.088	.16	ns
quadratic	63.897	1	63.897	4.94	4%
Aggregation x style					
difference in linear	54.489	1	54.489	4.21	5%
difference in quadratic	32.119	1	32.119	2.48	13%
Residual	414.268	32	12.946	-	-

Appendix (Cont.)

TABLE A. 5

Analysis of Variance Summary
Decision Time Performance

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	α
Within subjects	669.793	160	4.186	-	-
period	531.134	4	132.789	162.93	1%
period x aggregation	14.519	12	1.209	1.48	14%
period x style	7.351	4	1.838	2.26	7%
three way interaction	12.529	12	1.044	1.28	ns
error within	104.270	128	.815	-	-
Between subjects	76.986	39	1.974	-	-
aggregation	9.879	3	3.293	1.77	25%
style	1.057	1	1.057	.57	ns
aggregation x style	6.477	3	2.159	1.16	ns
error between	59.573	32	1.862	-	-
Total	746.779	199	3.753	-	-

Appendix (Cont.)

TABLE A. 6

Trend Analysis Summary
Decision Time Performance

A- Linear Trend Analysis for Period of Play

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	∝
Within subjects	505.5434	40	12.6386	-	-
linear trend	464.8336	1	464.8336	579.81	1%
aggregation x period	10.7746	3	3.5915	4.48	1%
style x period	.2823	1	.2823	.35	ns
three way interaction	3.9989	3	1.3330	1.66	ns
Residual	25.6539	32	.8017	-	-

B- Linear & Quadratic Trend Analysis for Aggregation Level

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	∝
Aggregation					
linear	5.702	1	5.702	3.06	10%
quadratic	3.780	1	3.780	2.03	ns
Aggregation x style					
differences in linear	.151	1	.151	.08	ns
differences in quadratic	6.273	1	6.273	3.37	8%
Residual	59.573	32	-	-	-

Appendix (Cont.)

TABLE A. 7

Decision Time
(in minutes)

Aggregation Level	Period					Average
	(1)	(2)	(3)	(4)	(5)	
AG1	74.1	33.9	30.0	18.1	10.5	33.1
AG2	74.5	29.1	20.3	14.6	9.0	29.5
AG3	53.8	24.4	20.1	15.4	10.2	24.8
AG4	57.8	28.4	18.8	16.4	13.5	27.0
Overall	65.0	28.9	22.3	16.1	10.8	28.6

Appendix (Cont.)

TABLE A. 8

Percentage Error in Contribution to Profit Estimation

Aggregation Level	Period					Average
	(1)	(2)	(3)	(4)	(5)	
AG1	9.6	7.8	13.4	5.2	2.1	7.7
AG2	18.7	16.2	8.5	5.4	1.7	10.1
AG3	13.4	0.7	1.2	1.1	1.7	3.6
AG4	29.3	3.4	7.8	10.5	3.6	10.9
Overall	17.8	7.0	7.7	5.5	2.3	8.1

Appendix (Cont.)

TABLE A. 9

Percentage Error in Decision Input Estimation

Aggregation Level	Period					Average
	(1)	(2)	(3)	(4)	(5)	
AG1	36.6	34.9	32.5	39.8	36.6	36.1
AG2	20.8	19.2	22.6	27.4	23.0	22.6
AG3	22.4	20.9	22.8	21.3	20.1	21.5
AG4	28.5	21.0	21.1	24.6	25.7	24.2
Overall	27.1	24.0	24.7	28.3	26.3	26.1

Summary of Hypothesis Tests

	Hypothesis	Stated Hypothesis Supported	Significance * level.	Comments
1)	Decision input estimation performance will tend to increase and then decrease as the aggregation level increases.	Yes	.01	Highly disaggregated reports produced very poor performance.
2)	Contribution to profit estimation performance will tend to increase and then decrease as the aggregation level increases.	Yes	.15	This result tended to fade period by period.
3)	Decision time will tend to decrease and then increase as the aggregation level increases.	Yes	.09	Decision time performance significant only at p=.25.
4)	Rate of learning is not affected by aggregation level.	Yes **	NS	Most rapid learning tended to take place with optimum report (AG3).
5)	Field independent subjects will perform better than field dependent subjects at decision input estimation.	No	NS	Field dependent subjects did slightly better on DIEP,
6)	Field independent subjects will do better than field dependent subjects at contribution to profit estimation.	Yes	.06	Field independent subjects (GEFT ≥ 13) outperformed field dependent subjects on CPEP.
7)	There will be no difference in decision time between field independent and field dependent subjects,	No	.15	Field dependent subjects (GEFT ≤ 12) took less time than field independent subjects.
8)	Rate of learning is not affected by cognitive style.	Yes **	-	-
9)	Decision making performance will be better on the less complex task (CPE) than the more complex task (DIE)	Yes	<.001	-
10)	Field independent subjects will outperform field dependent subjects by a greater margin on the more complex task.	No	.13	Field dependent subjects did better on more complex task.
11)	Rate of learning is not affected by task complexity.	No	Not available	Performance on the less complex task improved rapidly; on the more complex task no improvement took place.

* Significance levels are derived from analysis of variance in the case of multi-level independent variables and from t-tests (1-tailed) in the case of dichotomous independent variables.

** The null hypothesis is not rejected.

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