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Information Deficiency: Implications for Information Systems Design

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ABSTRACT

Determining the information needs of management has been an important area of MIS research. Yet most existing techniques focus only on user perceived importance of information. The notion of Information Deficiency integrates both user perceived importance and user perceived availability of an information category. This paper proposes that Information Deficiency is a more important indicator of how crucial a category is to the system designer in relation to other categories. A laboratory experiment that was used to test this notion is described and implications for systems design are discussed.

INTRODUCTION

The definition of information needs on the part of managers has been an important area of research in the management information systems (MIS) discipline as is evidenced by some recent review papers in the area (Taggart & Tharp, 1977; Bariff, forthcoming; Cooper and Swanson, 1979). A multitude of techniques that are used to define such information needs are discussed under the guidance of specific frameworks. Presumably, the imperative for this focus has been the concern that users may react negatively to an MIS that does not provide relevant and useful information (Mintzberg, 1976). It seems clear that, under the ideal case where the information needs of the users have been precisely determined, the system design implications are such that projects that address themselves to fulfilling the identified needs would receive high priority. The quality of an MIS after its implementation, is therefore dependent on the proficiency with which the information needs are determined.

Top management has special problems in determining information needs due to the more comprehensive and ad hoc environment of their decisions. Various guidelines for the definition of needs for these managers have been suggested such as the use of IBM's BSP (Business Systems Planning, 1978), Critical Success Factors (Rockart, 1979), Strategic Assumption Surfacing and Testing (Mason, Mitroff, and Barabba, 1980), and the analysis of environmental information (Ghymn and King, 1976). The Mason, et al., paper clearly

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addresses strategic planning needs; while Rockart contends that the CSF methodology is designed for management control and not strategic planning, its main targets are higher level managers. Munro and Wheeler (1980) tested this technique on senior and middle managers with relative success. One of the main objectives of this paper is to propose a methodology that may be uniformly applied across any management level for the purpose of eliciting information needs, and further, for prioritizing these needs to enable effective resource allocation concerning information systems projects.

Ever since Ackoff (1967) leveled the charge in his classic paper on the shortcomings of MIS, specifically pointing out that users may well be unable to define their own information needs correctly, a number of approaches to determine information requirements have been suggested in the literature. These techniques may be broadly classified under two categories--decision analysis or the top-down approach, and data analysis or the bottom-up approach. Briefly, the decision analysis approach focuses on the decisions themselves, using them as a guideline for determining information requirements. Simon's (1973) rationale for such an approach is representative of the advocates of this approach where he says that the analysis of the decision making system should precede that of the data system. Some of the authors who have reported the use of this approach include Kimmle (1972), King and Cleland (1975), and Taggart (1971). The data analysis approach concentrates on the flow of data in the organization rather than on the decisions (De Marco, 1978; Gane and Sarson, 1979; SADT; Warner, 1974). The rationale here according to Bariff (forthcoming) is to identify information requirements such that the status quo in the organization remains undisturbed. Authors reporting the application of this approach include Bushong (1971), Chadler and Nador (1972), and Edstrom, Broman, and Levin (1973). (In addition to these two broad approaches, Bariff (forthcoming) suggests the existence of hybrid techniques that are a mixture of the two types of approaches.)

In an effort to make a comparative evaluation between the two approaches, authors have reported mixed results. Nolan (1971), in a prescriptive manner, totally rejects the decision analysis approach. Kennedy and Mahaptra (1975) reported results from an empirical study that seemed to support the decision analysis. Munro and Davis (1977) attempted to compare the two approaches but the results were inconclusive.

THE CONCEPT OF INFORMATION DEFICIENCY

In most of the techniques that have been reported in the literature, the focus has been on attempting either directly or indirectly to capture those information categories or items that are perceived either by the user or a systems analyst as being needed in the context of particular decision making tasks. The drawback of such an approach is that as far as the MIS designer is concerned, the prioritization of the elicited needs is based solely on the strength of a stated need. We propose that the added dimension of perceived availability of a particular information category also plays a crucial role in determining how critical a particular information category is from the point of view of the MIS designer. The factor that determines how critical a particular information category is therefore not only dependent upon how much it is perceived as being needed by the decision maker, but also on the factor of how difficult the user perceives it is to obtain information of that particular category. The implication here is that, a particular information category may not even be a part of the elicited needs, simply because the prevailing perception of the user may be that the chances of obtaining it are very low (in the cases of the decision analysis mode) or because it may have escaped the analyst since it does not exist in the current flow of information in the organization (in the case of the data analysis mode). It is this critical gap that exists between how important a particular information category/item is to the user and the user's perception of how difficult it is to obtain, that determines the magnitude of its importance for MIS designers. This concept has recently been drawing some research attention in the marketing area (McEwen, 1978; Deshpande and Krishnan, 1980) in the context of designing consumer information programs. It does appear all the more applicable in the context that has been discussed below. The gap between the need strength and the user-perceived degree of availability of a particular information category is termed as Information Deficiency (ID). Given a particular information category, the following relationships are proposed:

1. High perceived importance and a high degree of perceived difficulty to obtain information of the given nature jointly result in a high degree of Information Deficiency.

2. Low perceived importance and a low degree of perceived difficulty to obtain information of the given nature jointly ressult in a low degree of Information Deficiency.

The following sections describe a laboratory experiment where this concept was applied. The results that were obtained are presented followed by the implications that they may have for MIS design.

METHODOLOGY

In order to examine Information Deficiency (ID) measures, 110 part-time MBA's participated in a two-phase experiment. The first phase consisted of reading a short case[1] dealing with the information needs of a chain of art supply stores. Respondents were asked to record demographic items and to list the relevant information items required in the case. No format or structure was suggested for this task. It was explicitly stated that accessibility was not an issue for consideration. These lists were used by the researchers to arrive at one composite list of the ten most frequently mentioned items.

In the second phase, the list of ten needs was distributed to the same respondents. They were then asked first to rate each item on a Likert scale for its importance where 1 was "not important at all" and 5 was "absolutely" essential." The same list of needs was again evaluated according to each item's perceived availability where 1 meant "impossible to get" and 5 meant "very easy to obtain."

Sample Description

There were 91 usable cases from both phases. The study chose evening MBA introductory MIS classes as the target group in order to find characteristics of most users--little or no systems experience and/or systems education and work experience in a variety of functional areas. Although five respondents were in MIS positions and fourteen had not worked full-time, the others have a wide range of user work areas with 4-5 years average experience. Most respondents were in the accounting/finance area (18%) with marketing and engineering the next popular business areas (10% and 8% respectively). Only 13% of the respondents worked in non-business related fields.

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[1] The details of the case may be obtained from the authors upon request.

The data relating to systems education and experience are interesting if viewed in the light of the pervasiveness of information systems (IS). When asked about systems education, the respondents were requested not to include the present MIS course in their reply. The average months of systems education (including company seminars, undergraduate courses, special training, etc.) were five. This is probably due to the fact that 20% of repondents indicated twelve months or more of systems education. In reviewing this item the majority of those students with some training had had only a programming course and not one that covered information requirements analysis. In the total sample there were 18% who had come from an Engineering background while 45% had business as an undergraduate degree. Eighteen percent came from math and the sciences. It is likely given these undergraduate degrees that a Fortran course or some computer-related course was required in their earlier training since their degrees were fairly recent, evidenced by the fact that the average age of the group is 25.6.

Approximately half of them had never used an information system (48%) and only 24% of them had used them longer than a year and a half. Even though over half of them were IS users, only 20% of the sample had ever participated on a design team. One wonders if any users were involved in drawing up the information needs for those systems.

Information Needs Composite List

There were seventy-two distinguishable information needs listed. The frequency of each was noted and the ten highest categories were used for the analysis. A certain measure of subjective interpretation was used in summarizing the list. While some respondents recorded "customer demographics," others may have listed specific ones (e.g., age, income). Table I shows the derived list. The categories were reordered randomly to avoid a bias in the scaling. In practice, one might take this list developed by end users and ask them to refine it further either by eliminating some items or by detailing precisely some of the more broad items.

There was an average of 5.7 information needs listed (the median was 5.4 and the mode was 5) so choosing the top ten was more than most people listed, allowing different viewpoints to be part of the development process.

Each information category was evaluated for perceived importance and availability. The availability scores were reverse coded prior to the computation of the Information Deficiency (ID) score. Table I shows the median values of both the importance and availability scores (the latter being recoded). We will now describe the procedures used to develop a prioritization of information needs through the concept of Information Deficiency.

Data Analysis

For each respondent the Information Deficiency concept was operationalized by computing an Information Deficiency score for each information category in the following manner.

$$\text{Information Deficiency Score} = \left(\begin{matrix}\text{Perceived Importance Score} + \\ \text{Perceived Availability Score}\end{matrix}\right)/2$$

As indicated in a previous section, the Information Deficiency Score captures the elements of both the importance of a particular information category to a specific decision context and the accessibility of that particular information category by taking the mean of each of two dimensions. It is assumed here that each of the dimensions, need and availability, are of equal

Table 1. Median Values of Perceived Importance, Perceived Availability, and Information Deficiency Scores

Information Category	Description	Perceived Importance	Perceived Availability	Information Deficiency Score
1	Stock turnover	3.8	1.750	2.759
2	Existing customer demographics	3.708	3.137	3.368
3	Potential customer demographics	3.677	3.781	3.611
4	Inventory by product	3.444	1.717	2.635
5	Inventory by store location	3.426	1.797	2.759
6	Competition	4.065	3.205	3.532
7	Profit margin	3.946	1.848	2.925
8	Number of product sold by store	3.984	1.871	2.975
9	Sales ($) by store	4.054	1.298	2.771
10	Advertising by store	3.209	1.983	2.618

weights. Table 1 shows the medians of the Information Deficiency scores by each information category.

Examination of the above table shows that the most critical information category concerns competitor information and the second most critical category concerns potential customer demographics. What is unknown from the table is the relative magnitudes of the deficiency scores for the two categories. In other words, while we know that the former is more critical in terms of MIS design implications than the latter, we do not know how much more critical it is in the relative magnitude sense. As we will see in the implications sections, knowledge of relative deficiency magnitudes proves to be invaluable when one talks about resource allocation decisions across different MIS projects. The ranking of the deficiency scores are unique only up to the ordinal level. What we are seeking then is a transformation of the available deficiency scores such that their relative magnitudes are realized and they become unique at the interval level. In order to obtain such a transformation, the Thurstone Case V model (Thursone, 1959) is employed. It is designed to take ordinal measures and restructure them to arrive at an interval measure. This technique will indicate relative priorities for the information categories.

The notion of comparative judgment underlies the Thurstone Case V model. A matrix of proportions that shows the proportion of respondents who had a greater deficiency score on information category "i" than on information category "j" is first constructed. Table 2 shows the results from the construction of such a matrix using the ID scores.

Each entry p (i,j) for (j>i; where i represents the row and j represents the column of the matrix) above the diagonal in the table was computed by first taking the sum of the following two quantities:

1. Number of respondents who had a higher deficiency score for information category "j" than for information category "i";

2. One-half the number of respondents who have an equal Information Deficiency score on both information categories "i" and "j." (This enabled us to resolve ties by equally distributing tied responses between the two cells (i,j) and (j,i).

This sum was then divided by the total number of respondents to give the upper half cell entries. Entries below the diagonal were computed by simply subtracting the corresponding upper half entry from 1.0.

$$p(j,i) = 1 - p(i,j)$$

The entry in the table marked with an asterisk is to be read as follows: 72.5% of the respondents had a higher deficiency score for information category 2, existing customer demographics, than for information category 1, stock turnover.[2]

By assuming homogeneous perception across each information category by the respondents,[3] the Thurstone Case V model may be simply expressed as follows:

$$R_i - R_j = Z_{ij}$$

where $(R_i - R_j)$ refers to the respondents' discriminal distance between stimulus i and

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[2]Self comparisons are set at 0.5

[3]Since the respondents themselves were the originators of the categories, such an assumption is partly justified; a split-half reliability test may also fortify the strength of such an assumption.

Table 2. Observed Proportions Table

Information Category "j"

	1	2	3	4	5	6	7	8	9	10
1	0.500	0.725*	0.769	0.422	0.450	0.769	0.571	0.582	0.505	0.433
2	0.275	0.500	0.642	0.262	0.253	0.593	0.308	0.308	0.203	0.225
3	0.231	0.358	0.500	0.555	0.203	0.461	0.264	0.264	0.143	0.159
4	0.578	0.738	0.445	0.500	0.528	0.829	0.681	0.659	0.554	0.521
5	0.550	0.747	0.797	0.472	0.500	0.835	0.648	0.648	0.527	0.467
6	0.231	0.407	0.539	0.171	0.165	0.500	0.242	0.275	0.396	0.171
7	0.429	0.698	0.736	0.319	0.352	0.758	0.500	0.532	0.406	0.363
8	0.418	0.692	0.736	0.341	0.352	0.725	0.468	0.500	0.373	0.363
9	0.495	0.797	0.857	0.446	0.473	0.604	0.594	0.627	0.500	0.434
10	0.567	0.775	0.841	0.479	0.533	0.829	0.637	0.637	0.566	0.500

*72.5% of the respondents had a higher Information Deficiency score on information category 2 than on information category 1.

stimulus j (see Green and Tull, 1978) and Z_{ij} is the standard variate (unit normal) associated with the proportion of respondents that score higher on stimulus i than on stimulus j. In our case, since we have already constructed the proportions matrix, the corresponding cell entries in the standard variates table may easily be obtained from a normal distribution table. Proportions less than 0.5 carry a negative value and those greater than 0.5 carry a positive value. Table 3 shows the standard variates entries corresponding to the proportions table (Table 2).

The unidimensional interval scale values for each information category are now computed by first adding the columns of Table 3 and computing a mean Z score for each category. These means represent the deviation of each information category scale value from the scale mean. Since, for an interval scale, we may choose an arbitrary zero point, we set the new scale value R* or the lowest category (advertising by store) at zero and recompute the new scale values of each of the other categories as follows:

$$\bar{Z}_{i,\,new} = \bar{Z}_{i,\,old} - \bar{Z}_{base,\,old}$$

where $Z_{i,\,old/new}$ is the old/new Z value of category i, the subscript base referring to the category that constitutes the zero point of the new scale. To illustrate, let us take the case of information category 1, stock turnover. The scale value as a deviation (Z) from the scale mean for this category is -.198. The base category (category 10, advertising by store) has a Z value of -.376. We set the R* of the base category at zero. The new value R* for category 1 becomes (-.198 - (-.376)) = 0.178. The newly computed scale values result in the unidimensional interval scale shown in Figure 1, which has a minimum value of zero and shows the relative magnitudes of the deficiency scores for each of the information categories.

RESULTS

This figure indicates that there are certain information categories that are much more critical to information systems development than others. Customer demographic (potential and existing) and competitive information are viewed as at least twice as critical as all other needs. Although needs 7 and 8 seem to have some merit, the five needs listed below the .2 level are clearly not as critical and may not be necessary for an information system with limited resources for development. Further, categories 3 and 9 on this figure do not reflect what users felt about their importance (shown in Table 1). Category 3 was not seen as critically important relative to the other items but this may be a reflection of its availability which ranked highest. The final scale value puts it as a priority item. What is important for designers (users and analysts both) is that they review these items and ask again, "Is this information category really critical or is it viewed as unimportant because users perceive that they can't get at the data anyway?" It may be very valid that having potential customer demographics will not improve the art supply business but the deficiency approach raises the issue of includding seemingly inaccessible items into the picture. Information category 9 shows the converse relationship. Sales by store were ranked as very important but because the information is so available it is not a priority item on which designers need spend their time.

Particularly interesting for this context is that non-financial information is in the spotlight. This is consistent with Rockart's (1979) observations using the CSF technique.

IMPLICATIONS

This method may allow some information categories to appear that under traditional

Table 3. Standard Variates Table

Information Category "j"

	1	2	3	4	5	6	7	8	9	10
1	0	.60	.74	- .20	- .13	.74	.18	.21	.01	- .17
2	- .60	0	.36	- .64	- .67	.24	- .52	- .50	- .83	- .75
3	- .74	- .36	0	.14	- .83	- .10	- .63	- .63	-1.7	-1.0
4	.20	.64	- .14	0	.07	.95	.47	.41	.14	.06
5	.13	.67	.83	- .07	0	.97	.38	.38	.07	- .08
6	- .74	- .24	.10	- .95	- .97	0	- .70	- .60	- .26	- .95
7	- .18	.52	.63	- .47	- .38	.70	0	.08	- .24	- .35
8	- .21	.50	.63	- .41	- .38	.60	- .08	0	- .32	- .35
9	- .01	.83	1.7	- .14	- .07	.26	.24	.32	0	- .17
10	.17	.75	1.0	- .06	.08	.95	.35	.35	.17	0
otal	-1.98	3.91	5.85	-2.80	-3.28	5.31	-0.31	0.02	-2.96	-3.76
($\overline{Z}$)	0.198	.391	.585	-.280	-.328	.531	-.031	.002	-2.96	-.376
R*	.178	.767	.961	.096	.048	.907	.345	.378	.080	0

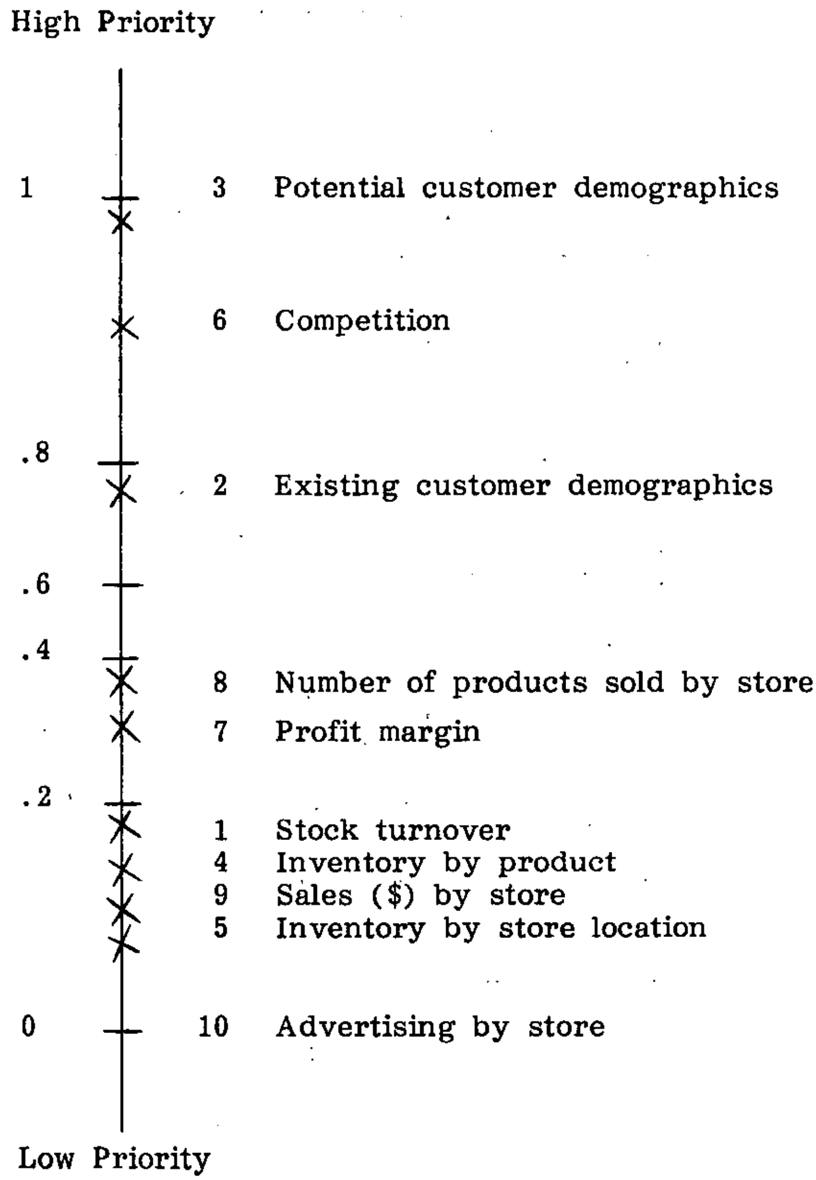

Figure 1. Interval Scale of Information Deficiency

information requirements analysis techniques might be left out. It not only allows these categories to appear but also gives a relative ranking with the availability dimension included. Rather than advocate the untested use of ID scores, we would suggest that maybe several refinements of the final scale be used. The study here had input from ninety-one respondents who were not committed to the IS. In a real setting there would probably be much fewer people involved even if clerical end users are included and the commitment may be more emotional (especially if it crosses departmental boundaries). Both of these differences emphasize the caution in using the scale dogmatically and only one time. But with the results shared by the group the scale could enlighten partipants about the needs of others. The use of an objective scale in dealing with the subjective nature of determining needs of several parties and the subjective decision of allocating the resources of MIS development could be an extremely useful tool for MIS management. The relativity of the needs could also suggest a time frame where a project concentrates on the categories with high ID scores in the first phase and the team knows that the next phase will be including the lower prioritized categories. In our example (see Figure I) the top three categories are clearly external information. Whereas a systems analyst may never have elicited these needs or realized the importance of this type of information, the technique allows these needs to surface and be glaringly in front of others. This may suggest a marketing information system for external information be developed over the next two years and in year 3 the team will begin work on an inventory and accounting system. It provides a tool for strategic planning in MIS at any level--corporate, departmental, managerial, etc.--for planning within projects and among projects.

The use of the Information Deficiency notion coupled with the scaling technique used perhaps has its greatest impact upon the effectiveness of the resource allocation process among competing information systems projects. While the degree of Information Deficiency that is associated with each information category is an indicator of how critical that particular category is to the system designer, the construction of the scale itself and the location of each category on the scale indicates the relative magnitudes of importance among the several categories. For example, in our case the results showed that category 2, existing customer demographics, scored approximately twice as much in this decision making context as category 8, number of each product sold by store, on the deficiency scale. This knowledge may be used as an important guideline to how much effort should be expended toward making information of each of these categories available to the decision makers. The scale is a valuable aid to the prioritization of information categories for data collection and information dissemination activities.

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