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THE CHARACTERISTICS OF SUBJECT MATTER IN DIFFERENT ACADEMIC AREAS [1]

ANTHONY BIGLAN [2]
University of Washington

Multidimensional scaling was performed on scholars' judgments about the similarities of the subject matter of different academic areas. One hundred sixty-eight scholars at the University of Illinois made judgments about 36 areas, and 54 scholars at a small western college judged similarities among 30 areas. The method of sorting (Miller, 1969) was used in collecting data. Three dimensions were common to the solutions of both samples: (*a*) existence of a paradigm, (*b*) concern with application, and (*c*) concern with life systems. It appears that these dimensions are general to the subject matter of most academic institutions.

One of the most easily overlooked facts about university organization is that academic departments are organized according to subject matter. Typically, each field of specialization has its own department, and the department in which there is more than one discipline is the exception. Presumably this system arises from the peculiar requirements that each area has for the organization of its research, teaching, and administrative activities. While the organization of university departments has received increasing attention from social scientists (Menzel, 1962; Oncken, 1971; Pelz & Andrews, 1966), the way in which subject matter characteristics may require particular forms of department organization has not been examined. The chief reason for this is probably that there has not been a systematic analysis of subject matter characteristics that could serve as a framework for such a study. It is obvious that such fields as physics and psychology differ in subject matter, but what is the nature of these differences? This article presents a multidimensional analysis of this problem. A subsequent article to be presented in this journal (Biglan, 1973) uses the analysis of this study to examine relationships between subject matter characteristics and department organization.

How can we get at the "important" characteristics or dimensions of academic subject matter? In this study it was assumed that scholars in the various areas are the best source of information about the characteristics of different areas; whatever dimensions they use in thinking about academic areas are considered to be important and worthy of further investigation. Nonmetric multidimensional scaling (Kruskal, 1964a, 1964b; Shepard, 1962) provides an ideal method for determining these dimensions. The method employs subjects' judgments about the similarities (or differences) among a set of stimulus objects. From this ordinal data, a map or array of the stimulus points is developed in a metric multidimensional space that "best fits" the original data about the similarity of stimuli. In this way the technique provides metric scaling of the stimuli and, at the same time, indicates the dimensions that underlie subjects' perceptions of them. The technique allows comparison among all academic areas within the same framework but does not restrict the analysis to the oversimplification associated with a single dimension.

At least two dimensions are likely to be used by scholars when they think about academic subject matter. First, Kuhn has argued that the physical sciences are characterized by the existence of paradigms that specify the appropriate problems for study and the appropriate methods to be used. It appears that the social sciences and nonscience areas such as history do not have such clearly delineated paradigms. If this is true, we should find a dimension that distinguishes paradig-

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[2] Request for reprints should be sent to Anthony Biglan, Department of Psychiatry, University of Wisconsin, 427 Lorch Street, Madison, Wisconsin 53706.

matic and nonparadigmatic fields. A second way in which scholars may perceive an area is in terms of its requirements for practical application. Thus, areas such as engineering and education are likely to be distinguished from areas such as English and chemistry.

METHOD

Multidimensional scaling of subject matter characteristics was first performed on data obtained from scholars at the University of Illinois. Since the dimensions obtained in this setting could simply reflect the way areas are organized at large, state-supported universities, the scaling was replicated at a small, denominational liberal arts college in the State of Washington. If the same dimensions are used by scholars at both of these institutions, then we can be more certain that we are getting at characteristics of academic areas that are general and important. In addition, semantic differential ratings of each area on each of six attributes were obtained from scholars at the small college as an aid to interpreting the scaling results.

Scaling technique. Kruskal's (1964a, 1964b) technique for nonmetric multidimensional scaling was used in the present study. Nonmetric multidimensional scaling employs ordinal data about the similarity among a set of stimulus objects and generates a configuration of points in an n-dimensional metric space, such that the distances among points in the metric space maximally correspond to the ordinal similarity data. The number of dimensions, n, is specified by the user. The scaling begins with a random n-dimensional configuration. In an iterative procedure this configuration is changed in small steps in order to maximize its fit with the similarity data. Kruskal's measure of fit is called "stress." It ranges from 0 to 100%. Typically, solutions are generated for different values of n, and one solution is chosen as "best" on the basis of its stress value and the interpretability of its dimensions.

The areas. Thirty-six areas were included in the Illinois scaling. Included were such areas as Agricultural Engineering, Physics, and Philosophy. The areas were chosen to include as diverse a sample as possible. The availability of structure and output data was also considered in choosing areas. In the small college replication, all of the areas in which the college offered courses were included for scaling. In addition, four areas that had been used in the Illinois scaling were also used in the replication in order to allow comparison of the results of the two analyses.

Judges. One hundred and sixty-eight faculty members at the University of Illinois served as judges of area similarity. They were distributed over the 36 areas of interest with no more than five and no less than three judges in any area. Whenever possible, judges within an area were distributed over academic rank and subdisciplines. Only six faculty members refused to participate in the study when asked.

All of the approximately 70 faculty members at the small liberal arts college were asked to make judgments about the similarity of academic areas. They were contacted through the Dean of the College, who wrote letters supporting the project. After one telephone follow-up by the Dean's office, 56 faculty members had returned completed judgments of which 54 were usable.

Procedure

Most methods of collecting similarities data require judges to rate or rank the similarity of all pairs of stimuli. In the case of the Illinois scaling, such methods would require 36(35)/2 or 630 responses from each judge. Since it did not appear that university faculty could be prevailed upon to this extent, a procedure requiring fewer responses of each judge was needed. Such a procedure has been proposed by Miller (1969) and was used in the present study. The method of sorting required judges to put areas into categories on the basis of their similarity. No limit was placed on the number of categories. The judgements of one subject about the similarities among areas may be represented in an $N \times N$ matrix whose rows and columns correspond to the academic areas of interest. Ones are placed in the cells of this matrix corresponding to the pairs of areas that were placed in the same category. Zeroes in cells indicate areas that were not placed in the same category. Summing over all judges' matrices provides a matrix whose cells indicate the number of judges who placed the pair of areas in the same category. Rao and Katz (1970) simulated the collection of similarities data using the sorting method. They compared the configuration obtained by scaling these similarities data with the known configuration they had started with. The correlation between the interpoint distances of the known configuration and the interpoint distance of the configuration obtained through the method of sorting was .81. This result compared favorably with the ability of other more common methods of collecting similarities data to recover the known configuration. Richards (in press) used real subjects in comparing the sorting method with a more common method of collecting similarities data. Canonical correlations between five-dimensional solutions for each method were .98, .96, .90, .60, and .46.

In collecting data at the University of Illinois, scholars were provided with 36 3 $\times$ 5 cards, each of which contained the name of *one* academic area. They were instructed to sort the cards into categories or piles on the basis of the similarity of the subject matter of each area. Data was typically collected in the scholar's office. Data from the small college replication were collected through the mails, using essentially the same procedure. In this case, the names of areas were presented on thirty slips of paper, and judges were asked to staple together the slips which they placed in the same category. Only one respondent appeared not to have understood these instructions. Upon completing the sorting task, scholars at the small college were asked to rate each area they had judged on the following bipolar adjectives: (*a*) pure–applied, (*b*) physical–nonphysical, (*c*) biological–nonbiological, (*d*) of interest to me personally–of little or no interest to me personally, (*e*) traditional–nontraditional, and (*f*) life science–nonlife science. Forms for these ratings were provided in a separate sealed envelope that judges were asked to leave sealed until they had completed the sorting task.

RESULTS

Scaling of the Illinois Data

Kruskal's (1964b) MDSCAL program (Version 4M) was used to scale the area similarity data obtained from both samples. For the Illinois sample, solutions were obtained in six, five, four, three, and two dimensions. Kruskal's index of goodness of fit between the similarity data and the multidimensional solution is called stress. The stress values for these solutions were .078, .101, .127, .226, and .311, respectively. Each solution was rotated to principal axes in order to aid interpretation.

The three-dimensional solution was chosen as the "best" solution, since all three of its dimensions were interpretable and its stress value was .23. Kruskal's suggested verbal evaluation for this stress value is "fair." He adds, however, that "where data values are heavily replicated, this evaluation is pessimistic, and larger stress values are acceptable [p. 9]."[3] Since there were 168 replications in the Illinois scaling, Kruskal's comment appears applicable.

The reliability of this configuration was evaluated by splitting the sample of judges into halves, obtaining a separate configuration for each half, and comparing these configurations. The judgments of all scholars who were in the first eighteen areas on an alphabetical list were placed in the first sample, and the remaining judgments comprised the second sample. A three-dimensional solution was obtained from the similarity judgments of each sample. The two configurations were compared by correlating the distances among each possible pair of stimuli in one configuration with the corresponding distances in the other configuration. This correlation was .88 ($N = 630$). Thus, it appears that in the present circumstances the sorting method of data collection yielded stable results.

There is a second way in which the method of data collection used in the present study may yield unreliable configurations. Stimuli may cluster rather than be evenly dispersed along the dimensions. This is not bad in itself, but with the data collection method used here the distances between points in different clusters may be less reliable than the distances between points in the same cluster. Visual inspection of the final three-dimensional solution from the Illinois sample did reveal clustering of areas. The areas could be grouped into eight clusters on the basis of their interpoint distances and visual inspection of the configuration. In order to test the reliability of intercluster distances, the two three-dimensional configurations described in the preceding paragraph were used. In both configurations, centroids were computed for each of the eight clusters of areas. The distances among the centroids in each configuration were then obtained. If intercluster distances are reliable, then there should be a high correlation between corresponding distances in the two configurations. This was, in fact, the case; the correlation was .88 ($N = 28$). Thus, although clustering of stimuli occurred, it appears that the intercluster distances are reliable.

A third problem associated with the method of sorting is that individual differences in the perceptions of areas cannot be evaluated in the usual ways (cf. Carroll & Chang, 1969). Since the areas were clustered in eight sets in the accepted solution, one method of evaluating agreement among judges would be to compare the eight separate three-dimensional solutions that could be obtained from judgments of scholars in each of the eight clusters. These solutions were obtained and interpoint distances in each solution were correlated with the distances in every other solution. The correlations ranged from .61 to .84. The average was .75. No configuration stood out as different from the rest. These results suggest that faculty members in our sample perceive the relationships among areas in substantially the same way, regardless of their own area.

Figures 1, 2, and 3 present plots of the three-dimensional solution. Each dimension is plotted against the other two so that there are three two-dimensional plots. In Figure 1, dimension one is plotted along the horizontal dimension, and dimension two appears vertically.

On the first dimension, physical science and engineering areas are at the extreme negative

[3] J. B. Kruskal, How to use M-D-SCAL, a program to do multidimensional scaling and multidimensional unfolding, March 1968. This paper and the accompanying computer program can be obtained by writing to J. B. Kruskal, Bell Telephone Laboratory, Murray Hill, New Jersey 07974.

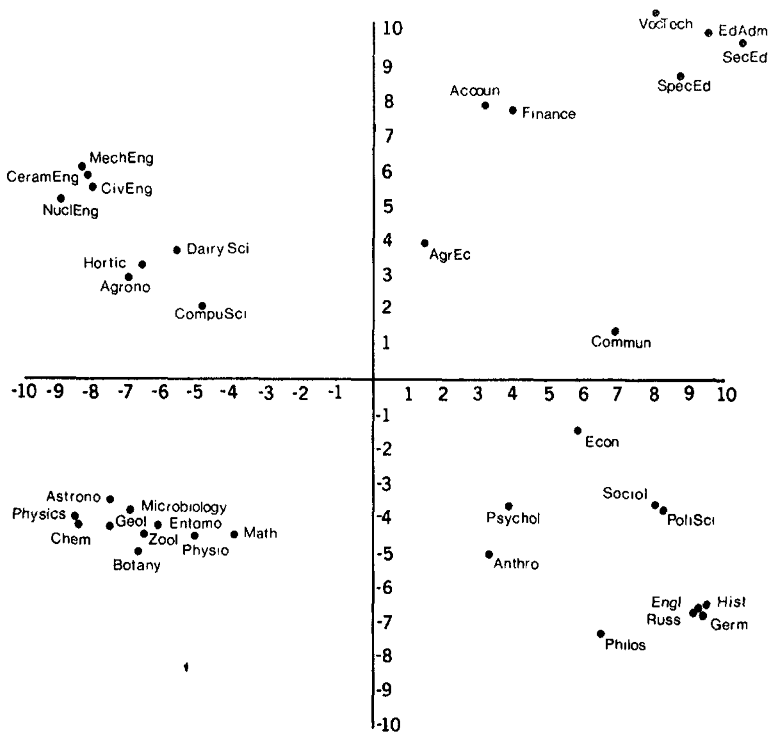

FIG. 1. Dimension I appears horizontally, and Dimension II appears vertically.

end, while humanities and education areas are at the extreme positive end. Biological areas are on the negative side, though closer to the origin than are the humanities. We thus have "hard" or science-oriented areas at one end of the dimension, social sciences toward the middle, and humanities at the other end of the dimension.

The second dimension (Figures 1 and 2) is a pure-applied dimension. At the extreme positive end are education areas. Accountancy, finance, and engineering areas are also at the positive end. On the negative end are physical sciences, mathematics, social sciences, languages, history, and philosophy. Unlike areas at the negative end of this dimension, those at the positive end are concerned with practical application of their subject matter.

The third dimension (Figures 2 and 3) appears to reflect the areas' concern with living or organic objects of study. Areas at the positive end all study such subject matter, while areas at the negative end do not. Thus, agricultural, biological, social science, and education areas are high on the dimension. The first two of these groups involve study of all living systems, while the latter two groups are concerned primarily with the study of man. On the negative end of this dimension are all of the areas that do not study living things. These areas do not seem to be widely dispersed, and it appears that the only characteristics they have in common is the absence of biological objects of study.

Scaling of Small College Data

For the small college sample, solutions in six, five, four, and three dimensions were obtained, and each was rotated to principal axes to aid interpretation. Stress values for these solutions were .054, .087, .124, and .184 for the six- through three-dimensional solutions, respectively. The four-dimensional solution was chosen as the "best" solution because all four of its dimensions were interpretable, and its stress value was "good" (.124) according to Kruskal's suggested evaluations.

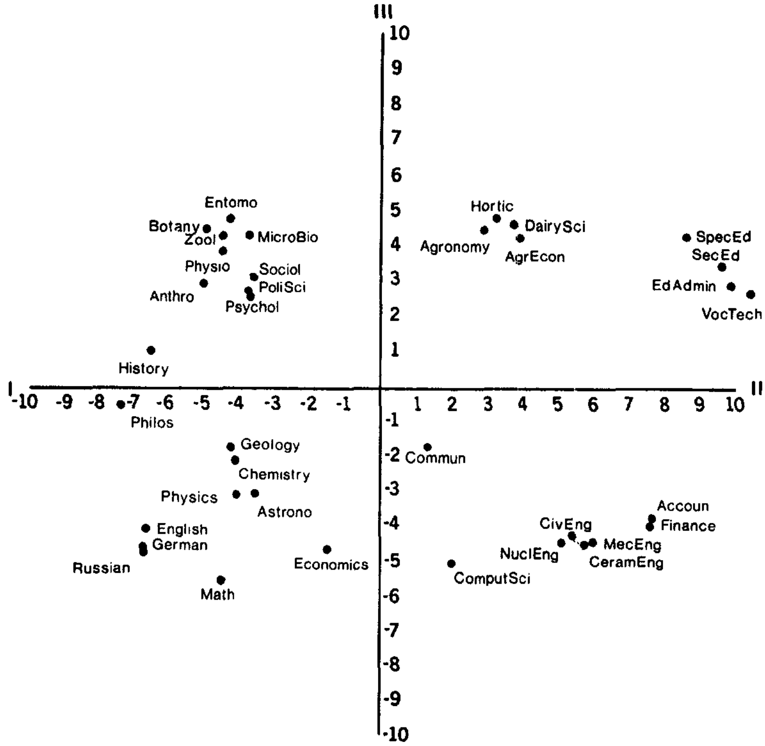

FIG. 2. Dimension II appears horizontally, and Dimension III appears vertically.

We may first ask if any of the dimensions of this solution are comparable to dimensions of the Illinois three-dimensional solution. Since 18 areas were common to both solutions, this question can be examined by correlating the positions of these areas on each dimension of the Illinois solution with their position on each dimension of the small college solution. Table 1 presents these correlations. The first dimension of the Illinois solution is virtually identical (r = .96) to the first dimension of the small college solution. The dimension distinguishes hard sciences from social sciences and humanities. The second dimension of the Illinois solution is highly correlated (r = − .81) with the third dimension of the small college solution. (The negative relationship is due to the inflection of the dimension on one solution and is of no consequence for interpreting the dimensions.) This dimension was interpreted in the Illinois solution as "concern with application." Visual inspection of the third dimension of the small college solution suggested the same interpretation. On the third Illinois dimension, areas with biological or social objects of study are distinguished from other areas. This dimension is highly related to the fourth dimension of the small college solution (r = .89). Thus, it appears that a dimension involving concern of areas with

TABLE 1

CORRELATIONS BETWEEN THE THREE DIMENSIONS OF THE ILLINOIS SOLUTION AND THE FOUR DIMENSIONS OF THE SMALL COLLEGE SOLUTION FOR 18 AREAS COMMON TO BOTH SAMPLES

Small college dimension	Illinois dimension		
	I	II	III
(I)	.96	−.35	−.03
(II)	−.47	.16	−.36
(III)	−.13	−.81	−.20
(IV)	.09	.07	.89

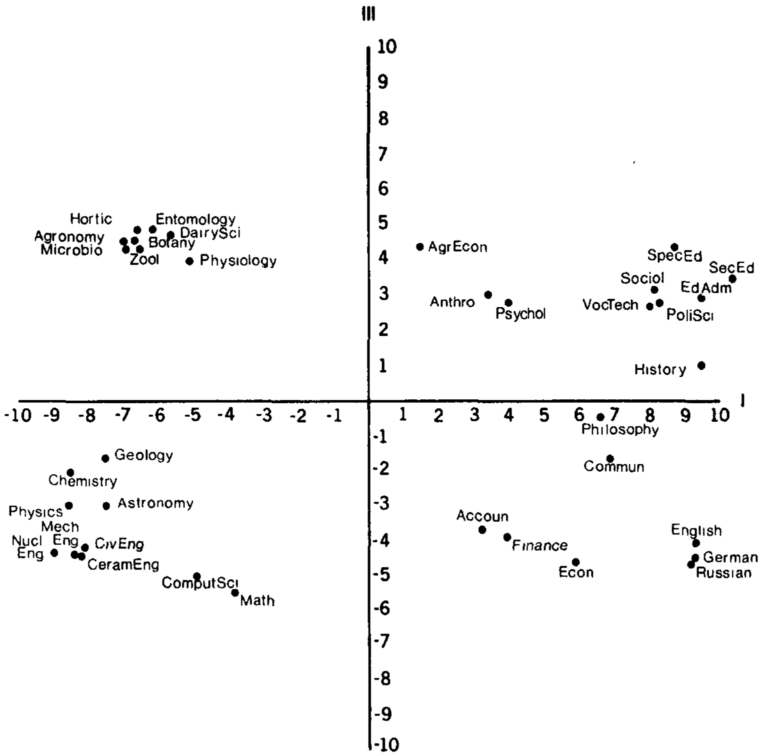

FIG. 3. Dimension I appears horizontally, and Dimension III appears vertically.

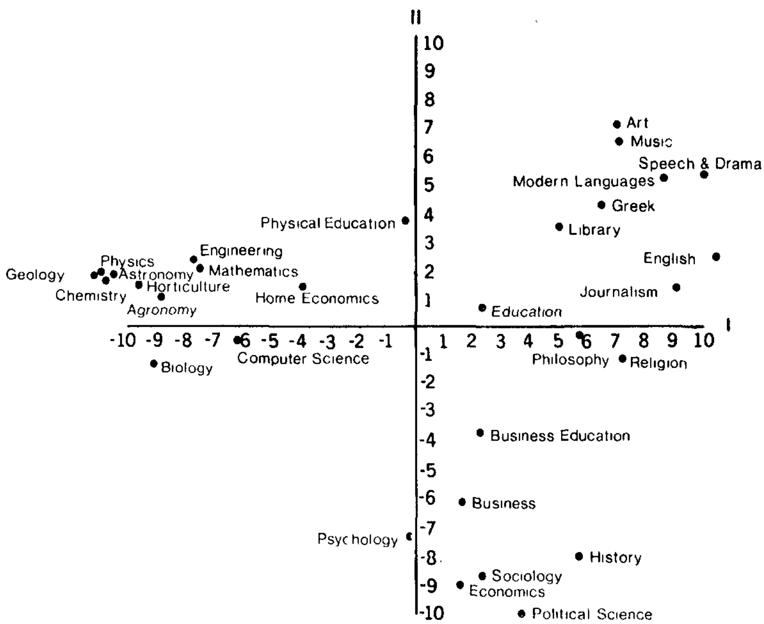

FIG. 4. Dimensions I and II of the small college solutions; Dimension I is the horizontal dimension.

biological or social processes is common to both solutions.

The second dimension of the small college solution is not strongly related to any of the Illinois dimensions. Figure 4 shows this dimension plotted against the first dimension of the small college solution. Art, music, speech and drama, and modern languages are at the positive end of this dimension, while social sciences such as political science, economics, and sociology are at the negative end. All of the areas that are a substantial distance from the origin are commonly found in liberal arts curriculae. Those at the positive end emphasize creative approaches to their subject matter, while those at the negative end emphasize empirical approaches. We may, therefore, tentatively label this dimension creative versus empirical liberal arts.

It is also useful to inquire about the overall similarity between the Illinois and small college solutions. This problem was examined by computing canonical correlations between the two solutions for the eighteen areas common to both. The three canonical correlations are .99, .92, and .88, indicating that the two solutions are highly similar.

Attribute Analysis

Interpretation of these dimensions becomes more clear when they are related to ratings of each area's attributes. Scholars at the small college rated each area on six bipolar adjectives. These ratings were averaged over all raters, and the average for each area was correlated with its position on each of the four dimensions obtained from the replication scaling. There were, thus, six attributes correlated with each of four dimensions. Table 2 presents these correlations.

Dimension I is correlated (.73) with the physical–nonphysical rating, indicating that the areas arrayed along this dimension differ in the extent to which they study physical objects. Two other attributes, biological–nonbiological and interesting–of no interest, were substantially related to the first dimension, but neither is so highly related to the dimension as to suggest a straightforward interpretation.

Dimension II is not strongly related to any of the attributes. It was suggested above that

TABLE 2

CORRELATIONS BETWEEN DIMENSIONS OF ACADEMIC AREA SCALING (SMALL COLLEGE SAMPLE) AND ATTRIBUTE RATINGS (N = 30)

Attribute rating	Academic area dimension			
	I	II	III	IV
Pure–Applied	−.01	.04	−.82	−.09
Physical–Nonphysical	.73	−.26	.40	−.26
Biological–Nonbiological	−.52	−.03	−.15	.66
Interesting–Of no interest	.50	−.16	.26	.36
Traditional–Nontraditional	−.22	−.15	−.51	−.00
Life science–Nonlife science	−.44	−.25	−.10	.68

this dimension involves creative versus empirical approaches to liberal arts. Dimension III was interpreted above as involving concern with application. This interpretation is supported by the correlation (r = − .82) between this dimension and the pure–applied attribute.

Dimension IV distinguishes biological and social fields from other areas. The fourth column of Table 2 shows that both the biological–nonbiological and life science–nonlife science ratings are correlated with dimension IV. However, neither correlation is high enough to justify labeling the dimension according to either attribute. The problem is that neither attribute deals with the extent to which the area is concerned with social processes. Perhaps the best name for this dimension is "concern with life systems."

DISCUSSION

Three characteristics of academic subject matter are perceived by scholars in both a university and a small college setting. The most prominent dimension (in terms of the variance it accounts for) distinguishes hard sciences, engineering, and agriculture from social sciences, education, and humanities. A good shorthand label for the dimension is "hard–soft." The dimension appears to provide one kind of empirical support for Kuhn's (1962) analysis of the paradigm. By "paradigm" Kuhn refers to a body of theory which is subscribed to by all members of the field. The paradigm serves an important organizing function; it provides a consistent account of most of the phenomena of interest in the area and, at the same time, serves to define those problems which require further research. Thus, fields that have a single paradigm will be characterized by greater consensus about content and method than will fields lacking a paradigm. Kuhn specifically designates physical and biological sciences as paradigmatic. He does not discuss agricultural and engineering areas, but they may also be considered to be paradigmatic, since they are grounded in their related pure fields. The areas at the extreme positive end—the humanities and education areas—are not paradigmatic. Rather, content and method in these areas tend to be idiosyncratic. The social sciences and business areas are also on the positive end of this dimension, but closer to the origin. These are fields that strive for a paradigm; but have yet to achieve one.

A second dimension underlying the way scholars view academic areas is the concern of the area with application to practical problems. Education, engineering, and agricultural areas are distinguished from hard sciences, social sciences, and humanities. The interpretation of this dimension is supported by its correlation with ratings of the areas on a pure-applied attribute dimension ($r = -.82$, $N = 30$). This dimension also appears to be used by scholars regardless of the kind of institution they are associated with.

Scholars also distinguish biological and social areas from those that deal with inanimate objects. This dimension also appears to be general to scholars in diverse institutions, since it was used by those at the University of Illinois and at a small liberal arts college. It is labeled "concern with life systems."

The one dimension that was not used by scholars at both institutions distinguished creative and empirical liberal arts areas. It is possible that this dimension did not appear in the Illinois solution because the areas that define the positive end of the dimension (art, music, and speech and drama) were not included in the Illinois judgment task. It is also possible that this dimension merely reflects the way that areas are grouped at the liberal arts college where we collected data.

This study has significance for at least two aspects of the scientific investigation of scholarly endeavors. First, investigations of the role of social structure in scholarly work tend to be restricted to a single or a few academic areas (Gouldner, 1970; Menzel, 1962; Pelz & Andrews, 1966). The subject matter differences that have been described here show why it may be unwise to generalize such studies to other academic areas. A subsequent article (Biglan, 1973) is addressed to this problem. Relationships are examined between the subject matter characteristics identified in this study and the structure and output of university departments.

Second, the analysis is relevant to the study of the cognitive processes of different areas. Increasing emphasis is being given to the way in which both the content and methods of a field are linked to the cognitive and perceptual processes of its members. Kuhn (1962) has shown how changes in scientific theory can be understood as a process of cognitive reorganization on the part of people in the field. Consistent with this, Piaget (1971) draws parallels between the conceptual systems of science and basic aspects of cognitive development. The present analysis provides a systematic framework for exploring the role of cognitive processes in academic fields. Specifically, it suggests that the three most important dimensions for characterizing the "cognitive style" of an area concern its use of a paradigm, its attention to practical application, and its concern with life systems. Moreover, the analysis presented here suggests the degree to which styles are similar in different areas.

In summary, three dimensions appear to characterize the subject matter of academic areas in most institutions. The dimensions involve (*a*) the degree to which a paradigm exists, (*b*) the degree of concern with application, and (*c*) concern with life systems. These characteristics may have an important effect on the type of structure and output that a department has. Moreover, these dimensions may provide a useful framework for studying the cognitive style of scholars in different areas.

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