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INTRODUCTION

Multidimensional scaling (MDS) algorithms have been available for almost two decades and have been proven useful in a large variety of research contexts. However, the interpretation that can be placed on MDS solutions has been the matter of some controversy (e.g. Beals, Krantz, and Tversky, 1968 ; Arabie and Boorman, 1973 ; Fraser, 1976). They can be viewed as corresponding to the basic processes/structures underlying cognitive judgments of perceived proximity. An alternative view is to regard them merely as a sophisticated sort of descriptive statistics.

This controversy has clear implications for the epistemological status of the dimensions of these MDS configurations. If they do correspond to the variables/criteria used by subjects in their proximity judgments, then one would expect that they reflect any existing differences in the judgment skills and motivations of the subjects as well as in their cognitive strategies.

That individual differences exist in MDS solutions has been well documented. What remains to be studied however is a) whether these differences are stable over time and across stimulus domains and b) whether they can be interpreted by existing theories on cognitive functioning, i.e. the manner in which individuals seek, structure, and process information. Research on these themes has been rather scant.

Silver, Landis and Messick (1966) reported consistent individual differences in the scaling of a set of random forms. These authors concluded that :

> "... since distinct viewpoints did appear, it is important ... that future research attempt to identify these differences by including measures of perceptual and cognitive styles and perhaps of personality and differences". (Silver, Landis, Messick, 1966, p. 71)

In two further studies, Landis and Slivka (1970) found that multidimensional points of view are related to such cognitive perceptual styles as field dependence-independence, leveling-sharpening, closure speed, cognitive interference, conceptual differentiation, as well as to certain measures of intelligence and dogmatism.

The literature on cognitive styles and information processing generally assumes that the number of dimensions present in an MDS analysis relates to the individual's cognitive differentiation, i.e. his ability to differentiate (Schroder et al., 1967 ; Sidanius and Ekehammar, 1976 ; 1977 ; Scott et al., 1979).

In the words of Bieri (1971), "the central focus of cognitive complexity [Bieri refers here to cognitive differentiation] is upon the ability of the individual to differentiate the behavior of others ... The more cognitively complex individual is assumed to have available a greater number of dimensions with which to construe the behavior of others than the less cognitively complex person".

Cognitive differentiation must be distinguished from "cognitive discrimination" and "cognitive integration" (Bieri et al., 1966 ; Schroder et al., 1967). Cognitive discrimination - also called cognitive articulation by Scott (1966) - refers to the degree to which a particular dimension is divided by an individual into a set of categories for distinguishing among stimuli. Cognitive integration measures the degree to which elements within a particular domain are interrelated (Tuckman, 1965, Schroder et al., 1967 ; Wyer, 1964 ; Scott, 1974).

The assumed relationship between the dimensionality of MDS solutions and cognitive differentiation is intuitively appealing and some authors (e.g. Schroder et al., 1967 ; Scott et al., 1979) have gone to the extent of suggesting to use multidimensional scaling as a measure of cognitive differentiation. Yet there is no direct empirical evidence that the cognitive differentiation skills of individuals is related to the number of dimensions found in individual MDS configurations. The very few studies (e.g. Mueller, 1974) which have tried to tackle this problem did not yield convincing results.

The objective then of the present research was to provide a direct test of the hypothesized relationship between cognitive differentiation and MDS dimensionality. More precisely the following hypothesis was offered :

H_1 : Subjects with greater cognitive differentiation ability exhibit MDS solutions of higher dimensionality.

METHOD

Subjects and Stimuli

Similarity data from an experiment conducted by Jain et al (1978) were used for the study. The stimuli consisted of the names of automobile brands. Three sets of automobile brand names consisting of, respectively, 25, 20 and 15 different brands were selected. These are presented in Table 1. The 15 brands of automobiles included in the third set are common across all the three sets. A pretest with a convenience sample had indicated that management students, who were to be the subjects in the experiment were familiar with the automobile brands selected. Subjects were randomly assigned to one of the three "treatment conditions" (i.e. they were either given 25, 20, or 15 brands to judge). There were 30 subjects in each "treatment condition".

Task

The subjects were asked to provide their judgements about the relative similarity of the n(n-1)/2 pairs of automobile brands, using a 7-point scale. They were requested to circle the number "1" if the pair was perceived to be very similar while the number "7" was to be used if the pair was perceived to be very dissimilar. Intermediate degrees of similarities were to be expressed by circling numbers lying between "1" and "7". The subjects were instructed to use their own criteria in judging the similarities. They were told to work at whatever pace seemed most comfortable to them. No financial incentive was offered to the subjects.

Measure of Cognitive Differentiation

Several measures of cognitive differentiation are proposed in the literature. A popular instrument to measure cognitive differentiation is the Interpersonal Discrimination Test developed by Bieri (1955). This test is a modification of Kelly's Role Concept Repertory Test - commonly called Rep Test (Kelly, 1955). Subjects in this test are requested to rate a number of persons from their close environment along ten dimensions. Their ratings are used to measure the number of unique dimensions each individual uses in his evaluations. Individuals who rate their set of persons in a similar way on several dimensions are designated as cognitively simple, whereas those who rate these persons differently on each dimension are designated as cognitively complex. Another possible measure of cognitive differentiation is Crockett's Role Category Questionnaire (1965). In this measure, subjects are required to identify eight different persons, each of whom fits a predetermined role, and then to describe each of these individuals as fully as possible in writing. The number of different dimensions listed in these protocols is viewed as a measure of cognitive differentiation. Alternatively, one could use the object sorting procedure of Scott (1962). In this test, subjects first generate a list of n stimuli and then sort them into as many groups as desired. Differentiation, or in Scott's words "dimensional complexity", is then measured by two measures labelled H and R.

Because of the nature of the stimuli selected for the study, a consumer version of Bieri's test developed by Pinson (1975) was used on this test. Consumers were first asked to indicate the names of eight products matching eight product descriptions and then to rate these products along eight dimensions (e.g., reliable, unnecessary) using a 6-point scale (ranging from -3 to +3). Cognitive differentiation is operationalised as the number of times the eight products are rated similarly along the eight dimensions. Low scores reflect greater cognitive differentiation abilities while higher scores reflect lower differentiation abilities.

Analysis

Usable similarity matrices were obtained from a total of 87 subjects. The similarity data for each subject was individually analysed via Takane, Young, and de Leeuw's ALSCAL (1977) procedure. To assure comparability across subjects, for the respondents in the 20 and 25 stimuli conditions only those similarity judgements which were common with subjects in the 15 stimuli condition were analysed. Individual configurations were obtained in 5 to 1 dimensions. To determine the best fitting dimensionality for each subject, the resulting stress values in different dimensionalities were analysed via Spence and Garef's (1974) MSPACE procedure.

Following current practice, the distribution of scores to Pinson's test was split into approximately equal fourths and subjects with scores in the top and bottom fourths were classified as simple and complex. Subjects in the middle fourths were excluded so as to obtain groups sharply contrasted with respect to cognitive differentiation.

To test H_1, an analysis of variance was performed with the number of dimensions - found adequate via the MSPACE procedure to fit the similarity data for each subject - as the dependent variable and cognitive differentiation as the independent variable. Contrary to expectations, simple subjects were found to use more dimensions than complex subjects. The results are presented in Table 2. Since similarity data for some of the subjects (those in 20 and 25 stimuli condition) were embedded in a larger set, Analysis of Covariance with the number of stimuli as covariates was used to examine the possible effect of such embedding. The regression co-efficient of the covariate was not found to be statistically significant ($p=0.92$) and the differences in the number of dimensions used by simple and complex subjects remained significant. The results are presented in Table 3.

DISCUSSION

The use of a greater number of dimensions by subjects with low cognitive differentiation ability is not consistent with the view that MDS presents an effective measure of cognitive differentiation.

Although these surprising results may be attributed to measurement and/or data analysis artifacts more substantive explanations can be tentatively offered.

The first explanation has to do with the ability of MDS in general - and of the particular algorithms used in this study to uncover the true underlying dimensions "used" by subjects in their judgements. It has often been said (e.g. Torgerson, 1965 ; Shephard, 1964 ; Stewart, 1974 ; Schroder ; 1971) that MDS solutions may lack accuracy when the stimuli are "highly analyzable" (Shephard, 1964 : 80-85) i.e. when they can lead to a larger variety of judgement responses. With "highly analyzable" stimuli the evidence shows that the MDS representations depend upon the type of selective attention applied by subjects to the different properties or subjects of the stimuli. Torgerson (1965) warned that :

> "...as one adds more and more obvious perceptual structure to a set of stimuli, the process underlying the judgements of similarity changes from what appears to be a rather basic perceptual one, to one which contains more and more cognitive features. And as the contribution of cognition goes up, the appropriateness of the multidimensional representation goes down." (p.383)

This also brings us back to the controversy on the nature of the extracted dimensions. The results obtained in this study are mainly disturbing for those who equate the MDS dimensions with the fundamental psychological dimensions of stimuli. They then will be less of a bad surprise for those who advocate the opposite view, namely that MDS dimensions simply are statistical constructs that help reproduce the subjects' original similarity judgements.

There is also some possibility of the MDS dimensions corresponding to different levels of integration. MDS allows us to identify the dimensions but it tells us little about the information integration process followed by subjects in their similarity judgements. As suggested by Schroder et al. (1967 : 181-184) individuals with high cognitive differentiation skills may be incorporating several sub-dimensions into "super-dimensions" and hence appear to require fewer dimensions to recover the original similarity data.

The ability to integrate "sub-dimensions" into "super-dimensions" would seem then to be directly related to the familiarity with the properties of the stimuli (particularly the ones which are instrumental) as well as to the perceived complexity of the task. The following two hypotheses were then advanced:

H_2 : Subjects with greater familiarity with the instrumental stimuli properties will exhibit MDS solutions of lower dimensionality.

H_3 : Subjects who perceive the judgement task to be complex are likely to exhibit MDS solutions of higher dimensionality.

To test H_2, subjects were asked to indicate, on a 7-point scale, the extent of their "familiarity with the characteristics of automobiles which are important in providing usage satisfaction". They were requested to circle the number "7" if they were very familiar with the characteristics and the number "1" if the characteristics were very unfamiliar to them. Subjects scoring above 5 were assigned to the high familiarity condition and those scoring below 4 were assigned to low familiarity condition. Subjects in the middle were excluded so as to obtain groups differing sharply with respect to product characteristics familiarity. A t-test was performed to examine the difference in the number of dimensions utilized by subjects differing in terms of product characteristics familiarity. As expected, subjects less familiar with automobile characteristics exhibited higher dimensionality than those more familiar with them ($p=0.03$).

Task complexity was measured by asking the subjects to indicate on a 7-point scale "how complex are the automobiles for you to evaluate". A higher score reflected greater perceived task complexity. Subjects scoring above 5 were assigned to high task complexity condition and subjects scoring below 3 were classified to the low task complexity condition while those in the middle were excluded from the analysis. A t-test indicated that the subjects who perceived the evaluation task to be complex exhibit a significantly higher dimensionality than those who perceived it to be less complex (p=0.00).

In conclusion, while it is true that the empirical evidence provided by this study is of a very tentative nature, it would not be completely wise to reject the possibility that the dimensionality of MDS is a poor indicator of the cognitive differentiation ability of subjects in as much as one is not able to distinguish between "sub-dimensions" and "super-dimensions". Future researchers might be well advised then to focus on information process rather than state in their investigation of "true" dimensionality.

TABLE 1

LIST OF AUTOMOBILE BRANDS USED AS STIMULI

Automobiles	Stimuli Set Of 25	Stimuli Set Of 20	Stimuli Set Of 15
Datsun-210	x	x	
VW Rabbit	x	x	x
Chrysler Cordoba	x		
Lincoln Continental	x	x	x
Honda Accord	x		
Ford Ltd.	x	x	
Ford Thunderbird	x	x	x
Chevrolet Impala	x	x	x
Toyota Corolla	x	x	x
Ford Pinto	x	x	x
Oldsmobile Cutlass	x	x	x
Mercedes 240D	x	x	x
Mercury Cougar	x	x	x
Ford Granada	x	x	x
Oldsmobile Tornado	x		
Dodge Aspen	x	x	x
AMC Matador	x	x	
Plymouth Fury	x	x	x
Ford Mustang II	x		
Volvo 240 Series	x	x	x
Buick Skylark	x	x	
Chevrolet Chevette	x	x	x
AMC Gremlin	x	x	
Buick LeSabre	x		
Cadillac Eldorado	x	x	x

x = Brand name included in the stimuli set.

TABLE 2

EFFECT OF COGNITIVE DIFFERENTIATION ON THE NUMBER OF DIMENSIONS IN MDS REPRESENTATION OF SIMILARITY JUDGMENT

A. ANOVA RESULTS

Source of Variation	DF	Mean Square	F	P
Cognitive Differentiation	1	8.595	4.552	0.03
Residual	40	1.888		

B. CELL MEANS

	Mean Number of Dimensions
Complex Subjects	1.95
Simple Subjects	2.85

TABLE 3

EFFECT OF COGNITIVE DIFFERENTIATION ON THE NUMBER OF DIMENSIONS IN MDS REPRESENTATION CONTROLLING FOR THE STIMULI CONDITION

Source of Variation	DF	Mean Square	F	P
Number of Stimuli	1	0.016	0.008	0.92
Cognitive Differentiation	1	8.595	4.439	0.04
Residual	39	1.936		

REFERENCES

Arabie P., and S.A. Boorman, "Multi-dimensional Scaling of Measures of Distances on Partitions," Journal of Mathematical Psychology, 10, 1973, 148-203.

Beals R., D.H. Krantz and A. Tversky, "Foundations of Multi-dimensional Scaling," Psychological Review, 75, 1968, 127-142.

Bieri J., "Cognitive Complexity - Simplicity and Predictive Behaviour," Journal of Abnormal and Social Psychology, 51, 1955, 263-268.

Bieri J., A.L. Atkins, S. Briar, R.L. Leaman, H. Miller and T. Tripodi, Clinical and Social Judgement : The Discrimination of Behavioural Information, New York : John Wiley & Sons, 1966.

Bieri J., "Cognitive Structures in Personality," in H.M. Schroder and P. Suedfield, eds., Personality Theory and Information Processing, N.Y. : The Ronald Press, 1971, 178-208.

Crockett W.H., "Cognitive Complexity and Impression Formation," in B.A. Maher, ed., Progress in Experimental Personality Research, Vol. 2, New York : Academic Press, 1965.

Driver M.J., "Conceptual Structure and Group Processes in an Inter-Nation Simulation. Part One : The Perception of Simulated Nation," Educational Testing Service Research Bulletin, RB 62-15, 1962.

Fraser C.O., "Cognitive Strategies and Multidimensional Scaling," British Journal of Psychology, 67(3), 1976, 399-406.

Jain A.K., N.K. Malhotra and V. Mahajan, "The Effect of Missing Values in Similarity Judgements on Configuration Recovery in MDS Models : An Experimental Examination," A Paper presented at the First Joint Meeting of the Psychometric Society and the Society for Mathematical Psychology, McMaster University, Hamilton, Ontario, August, 1978.

Kelley, G.A., The Psychology of Personal Constructs, Vol. I and II. New York : Norton, 1955.

Landis D., and R.M. Slivka, "Some Determinants of Multi-dimensional Points of View : Two Studies," Perceptual and Motor Skills, 31, 1970, 659-670.

Mueller W.S., "Cognitive Complexity and Salience of Dimensions in Person Perception," Australian Journal of Psychology, 26(3), 1974, 173-182.

Pinson C., "A Consumer Cognitive Differentiation Test," Working Paper, INSEAD, Fontainebleau, France, 1975.

Schroder H.M., M.J. Driver and S. Streufert, Human Information Processing, N.Y. : Holt, Rinehart and Winston, Inc., 1967.

Schroder H.M., "Conceptual Complexity and Personality Organisation," in H.M. Schroder and R. Suedfeld, eds., Personality and Information Processing, N.Y. : The Ronald Press, 1971, 240-273.

Scott W.A., "Cognitive Complexity and Cognitive Flexibility," Sociometry, 25, 1965, 405-414.

Scott W.A., "Brief Report : Measures of Cognitive Structure," Multivariate Behavioural Research, 1, 1966, 391-395.

Scott W.A., "Varieties of Cognitive Integration," Journal of Personality and Social Psychology, 30, 1974, 563-578.

Scott W.A., D.W. Osgood and C. Peterson, Cognitive Structure : Theory and Measurement of Individual Differences, N.Y. : Halsted Press, 1979.

Shephard R.N., "Attention and the Metric Structure of the Stimulus Space," Journal of Mathematical Psychology, 1, 1964, 54-87.

Sidanius J., and B. Ekehammar, "Cognitive Functioning and Socio-political Ideology : A Multi-dimensional and Individualised Analysis," Scandinavian Journal of Psychology, 17(3), 1976, 205-216.

Sidanius J., and B. Ekehammar, "Cognitive Differentiation and Socio-politico Ideology : An Exploratory Analysis," Psychological Reports, 41, 1977, 203-211.

Silver, C.A., D. Landis and S. Messick, "Multi-dimensional Analysis of Visual Form : An Analysis of Individual Differences," American Journal of Psychology, 79, 1966, 62-72.

Stewart T.R., "Generality of Multi-dimensional Representations," Multivariate Behavioural Research, 9, 1974, 507-519.

Spence, I. and J. Garef, "The Determination of the Underlying Dimensionality of an Empirically Obtained Matrix of Proximities," Multivariate Behavioural Research, 9, 1974, 331-342.

Takane Y., F. Young and J. de Leeuw, "Nonmetric Individual Differences Multidimensional Scaling : An Alternative Least Squares Method with Optimal Scaling Features," Psychometrika, 42, 1977, 7-67.

Torgerson W.S., "Multi-dimensional Scaling of Similarity," Psychometrika, 30, 1965, 379-393.

Tuckman B.W., "Integrative Complexity and Attitudinal Orientation," Perceptual and Motor Skills, 21, 1965, 838.

Wyer R.E., Jr. "Assessment and Correlates of Cognitive Differentiation and Integration," Journal of Personality, 32, 1964, 495-509.

LIST OF INSEAD RESEARCH WORKING PAPERS

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