Cary, J. W. (1988). Information Loss in Grid Analysis. In F. Fransella and L.F. Thomas (eds.) *Experimenting with Personal Construct Psychology*, Routledge and Kegan Paul, London, pp. 389 399.
(This paper shows some experiments comparing Galileo MMDS to anlayses used for PCP Grid analysis using interval and categorical data and NMMDS)

contrasts and display selected aspects of the available multi-dimensional space. One aim is to get a better handle on what this means, how it can be seen, how changes can be recognised and how therapeutic interventions may be implemented. So, for future developments watch this space.

References

Brennan, M. and Kirkland, J. (1985). Comparison of perceptual dimensions uncovered from infant-cry signals using the method of pair-comparisons and semantic differential. *Scandinavian Journal of Psychology* 26, 12–20.

Cutting, J. E. and Posner, B. S. (1974). Categories and boundaries in speech and music. *Perception and Psychophysics* 16(3), 564–70.

Kirkland, J. and Brennan, M. (1984). Profiles obtained from clustering behaviours in situations rated on temperament dimensions. *The Exceptional Child* 32, 31–5.

Miller, G. A. (1956). The magical number seven, plus or minus two. *Psychological Review* 63, 81–97.

Zeeman, E. C. (1976). Catastrophe theory. *Scientific American* 234, 65–83.

Chapter 4

Information loss in grid analysis

J. W. Cary

The use of grids, or repertory grids, in personal construct analysis has two principal functions: the elicitation of constructs and the determination of the cognitive structure pertaining to individuals' use of constructs and perception of elements. There then follows a subsidiary, but no less important, task of establishing a means of interpreting these structures and of communicating the patterns within the structures. In this paper the focus of interest is the process of measurement employed to construct a grid and the implications of the level of measurement in determining the accuracy of the structure of the concepts used in the grid. In examining the impact of the level of measurement, the process of analysis to establish the structure in the measurements taken will also be indirectly considered.

Techniques for collecting grid data are well established (Fransella and Bannister, 1977); considerable attention has also been given to techniques for the analysis of grid data (e.g. Slater, 1972; Pope and Keen, 1981; Shaw, 1981) and to the implication of different forms of analysis on the outcomes of grid analysis (Rathod, 1981). Categorical-, ordinal- and interval-level data are all widely used in texts on grid technology and in published applications of the use of grids. Current preference seems to be for the use of rating scales. While, perhaps, it is implicit that measurement theory is widely understood by grid practitioners, there is a suprising lack of explicit examination of the effect of measurement level on the accuracy of structures derived from grid data. This may be due largely to the use in personal construct theory of a categorical approach to elicit constructs from a set of derived or supplied elements.

There are two main classes of use for grids in personal construct psychology: the psychotherapy situation and the research situation where grids from larger numbers of subjects are obtained. The first situation is characterised by a 'one on one' interaction, with the grid being used as an aid to diagnosis and communication between the therapist and the client. In this situation the outcomes of grid analysis can be modified by communication between the therapist and the client; but misinformation or inadequate analysis may create a false agenda for the therapeutic interaction. In the research use of the grid, particularly where the number of subjects is greater than one, measurement and analysis are more critical to the validity and particularly the reliability of derived cognitive structure.

Information potentially available in a grid can be lost both in the process of measurement and in the process of analysis which establishes the pattern or structure in the measurements taken. Principal-components analysis has been the most enduring and the most popular of the non-classificatory techniques of grid analysis. It will be used in this paper for the analysis of the data sets to be considered. A metric multi-dimensional scaling technique which uses data which has ratio-level characteristics will also be presented. We turn now to a consideration of potential effects of the level of measurement.

An experimental study of country images

To examine the effects of different levels of measurement on grid analysis a study was undertaken of the comparative images of products made in different countries with data collected at varying levels of measurement precision. Comparative image studies have been reported frequently in the marketing and behavioural literature (e.g. Jaffe and Nebenzahl, 1984).

Data were gathered at three levels of measurement exhibiting categorical, interval and ratio characteristics, respectively. Twenty honours-level university students were respondents for the three levels of data-gathering, with three questionnaires being administered to the same subjects over a period of one week. Categorical

level data was collected in standard repertory-grid format with five elements (countries) compared by seven constructs (attributes) using a dichotomous choice. Interval-level data were obtained by rating the country elements on attribute constructs using a seven-point semantic differential scale. Ratio-type data was derived by pairwise comparison of all country elements and attribute constructs. The ratio unit of measurement was established by arbitrarily defining the distance between two relevant concepts as being 100 units. Subjects then used this measurement standard to estimate distances between all elements and concepts: perfect correspondence between two concepts being represented by zero and large differences unconstrained by any upper numerical limit. Pairwise comparison involved collection of sixty-six 'pieces' of information in contrast to thirty-five data observations for the other two levels of data collection. For each of the three questionnaires the same order of presentation was used for all subjects.

The categorical and interval data were analysed using principal-components analysis in Slater's INGRID program. The ratio data were analysed by metric multi-dimensional scaling (MMDS) using the GALILEO program (Woelfel and Fink, 1980) based on Torgerson's (1958) modification of Young and Householder's (1938) procedure for converting inter-point distances to a scalar-products matrix which is then transformed to principal axes (by the same process as principal-components analysis of a covariance matrix). The GALILEO program is designed to accommodate eigenvalues of less than zero, thus giving an indication of the degree of intransitivity between concept comparisons.

The underlying structure of relationships between concepts, both elements and constructs, for each of the data sets is shown in Figure E4.1. The first two dimensions for the three data sets were manually rotated to achieve a best fit. The matrices resulting from the two conventional forms of grid data-gathering are fully resolved in four dimensions with the first two dimensions accounting for 94 per cent of the variance in both cases. The analysis of the ratio data set produced six dimensions in real space and six dimensions in imaginary space (negative eigenvectors), with the first two dimensions accounting for 72 per cent of the real space.

A comparison of the patterns in the three data sets (Fig. E4.1) indicates that the general 'order' of spatial relationship is consistent for the three situations and that the concept locations are spatially

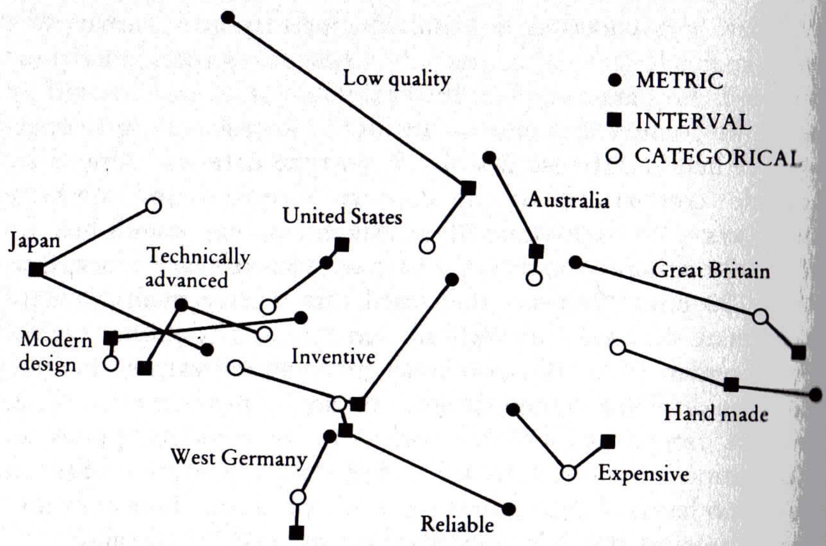

Figure E4.1 First two dimensions for three levels of measurement (dimensions for each set manually rotated for best fit)

closer for the categorical and interval data sets. It is not possible to establish which set and which form of analysis provides the most accurate structure; this problem will be pursued later. If it can be assumed that the metric analysis ought to produce the most accurate result then there are significant discrepancies in the relationships between concepts for the categorical and interval data.

A selective interpretation of the two-dimensional relationships (Fig. E4.2) indicates some differences between the three data sets. For the categorical data, the United States [6] is seen as Technically Advanced [1] and Inventive [12]; and Australia [7] and the United States [6] are associated with Low Quality [11]. This latter association also applies for the interval data but there is no close association between the United States and Technically Advanced. Interpretation discrepancies would be reduced if we adopted Slater's (1972) advice that the constructs be projected onto the circumference of a circle centred on the origin. This seems to be rarely done in practice. But such an approach also reflects that the data are standardised in the analysis, with the constructs having a standard deviation of 1.

For the ratio data, Hand Made [10] and Low Quality [11] are not associated with any country; and all countries are seen as less Reliable [5]. The magnitude of the distance of concepts 10 and 11

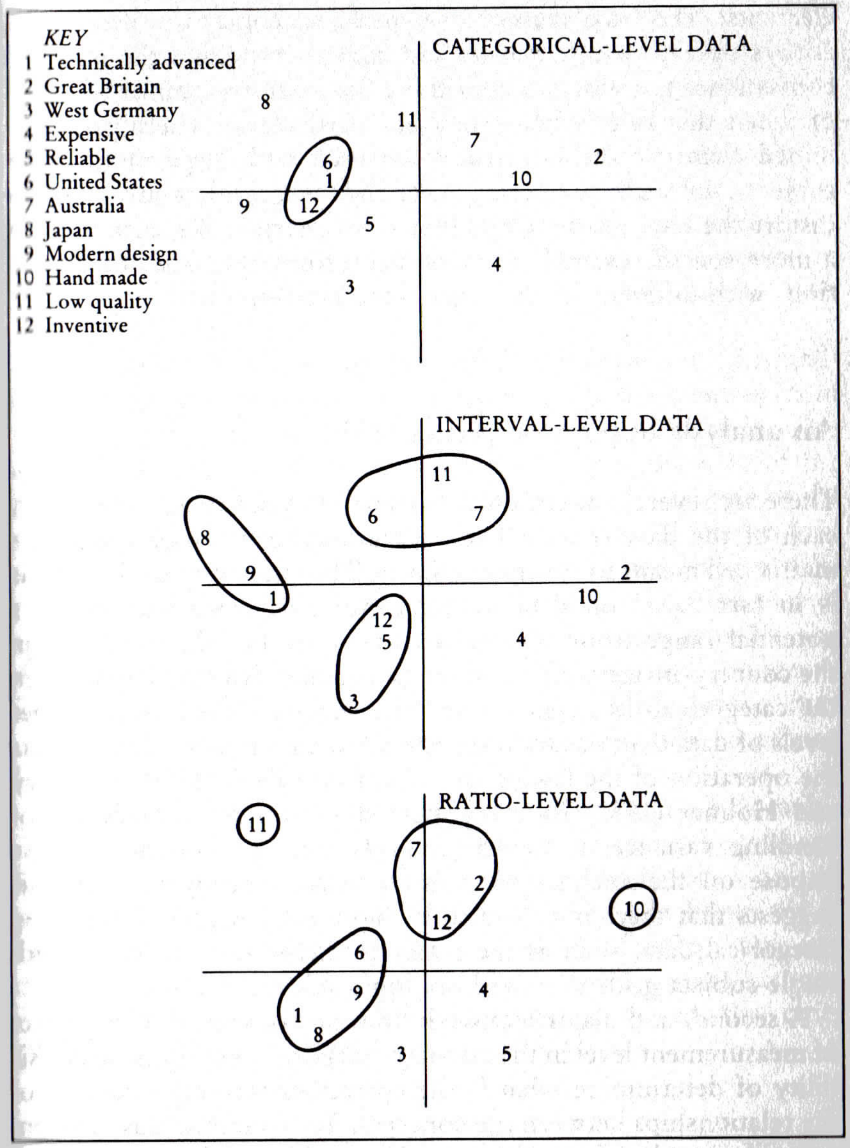

Figure E4.2 Interpreting the concept structures for three levels of data on first two dimensions

from the other concepts in the ratio analysis indicates the potential danger of the natural inclination to assume metric properties exist once we spatially depict categorical and interval data in Cartesian-type plots. The ratio data indicates that these two 'constructs' were not relevant to a consideration of the countries chosen as elements. The 'rule' adopted by personal construct theorists to always operate with elements and constructs within the range of convenience is a wise one to follow, but often we cannot be aware of when this rule is being broken, particularly where predetermined elements and constructs are used with large numbers of subjects. In such cases categorical and interval data are likely to distort the true relationships between concepts. We turn now to a more specific example of potential information loss, or distortion, with different levels of grid measurement.

An analysis of physical structure

There are several limitations to the analysis presented so far. First, each of the data sets used to measure country images comprise matrix cell means for twenty subjects. Thus the categorical analysis is in fact based on data with interval characteristics, having a potential range from zero to one. For any individual subject in the country-image analysis, there is a greater discrepancy between the categorical-data analysis and the analysis based on the other levels of data than occurs when the mean data is used. This reflects the operation of the law of large numbers. Beail (1984) and Cary and Holmes (1982) have highlighted some of the problems of handling variance in consensus grids and the limitations these impose on the analysis of multiple grids. The present analysis suggests that there is a need to be more circumspect about using categorical data, such as the common dichotomous choice, with single-subject grids than with multiple-subject grid sets.

A second, and major, constraint on the assessment of the effect of measurement level in the country-image data sets is the impossibility of determining what is the correct underlying structure of the relationships between the concepts. To overcome this problem we will consider the analysis of relationships of known physical structure. The data base is provided by the Cartesian coordinates of a rectangular pyramid with five points where the planes intersect. The Cartesian coordinates of these points are P1 (−4, 2, −4); P2 (−4, 2, 6); P3 (4, 2, 6); P4 (4, 2, −4); and P5 (0, 8, 1).

Ratio-level data for MMDS analysis were the ten inter-point distances between the five coordinate points. The five Cartesian coordinates were also used as ratio-level data in a grid format for

principal-components analysis. Interval-level data were created by rescaling the Cartesian coordinate distances on a seven-point scale. Categorical data were created by categorising the coordinate points as being either above or below the mid-point of the range of coordinate values. The interval and categorical data were analysed in grid format using principal-components analysis. The variance for all data analyses is fully expressed in three dimensions. Comparisons of the resulting structures can thus be observed in three-dimensional plots of the coordinates produced by each analysis (Fig. E4.3).

Analyses of the ratio-level data by both MMDS and principal-components analysis produce true symmetrical representations of the original rectangular pyramid. The interval-level data produce a small distortion of the original structure (after the base of the pyramid is rotated to a horizontal position) and in the case of the categorical-level data there are major distortions of the original structure – the base of the pyramid is not a flat plane and a vertical gravity line from the apex of the pyramid falls outside the base of the pyramid. In the less precise data sets the spatial order and direction may be correct, but the distances between 'concepts' indicate considerable measurement error. Such errors may considerably distort specific interpretations of grids containing larger numbers of concepts.

The accuracy of principal components analysis and metric multi-dimensional scaling in resolving the true structure of the grid sets has not been specifically considered. Both methods appear to give similar results for the two ratio data sets shown in Figure E4.3. However, in a comparative analysis of matrices of inter-city distances, metric multi-dimensional scaling gives a more accurate representation of the spatial relationship between the cities (Woelfel and Fink, 1980).

Concluding comments

It can be concluded that the distances between concepts will be less accurate for less precise levels of measurement. Less precise forms of measurement produce degradation in the 'true' structure of relationships between concepts – both elements and constructs. While this is an obvious concern for research uses of the grid –

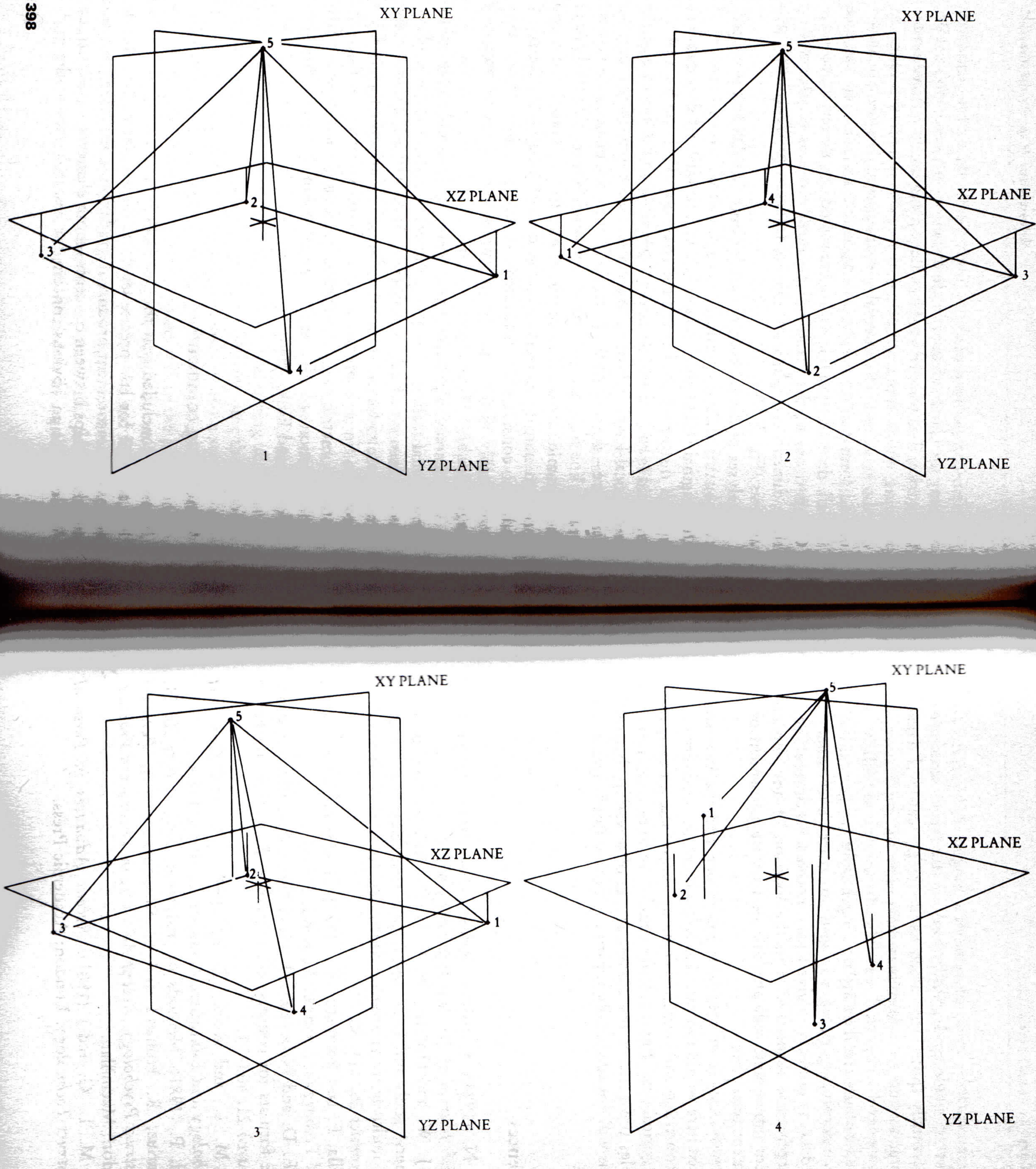

Figure E4.3 Three-dimensional structures for three levels of data measurement: (1) ratio data (MMDS analysis of inter-point distances), (2) ratio data (principal components of Cartesian coordinates), (3) interval data, (4) categorical data where acceptable levels of reliability ought to be desired – in the use of single grids, distortions of the 'true' structure will be potentially quite large when using categorical-level data. The resulting misinterpretation may have serious implications. For aggregate-level categorical data the distortions are likely to be lessened because the data are no longer truly categorical.

When measuring changes in grid structures over time, categorical data are unlikely to give an acceptable level of result because the larger error associated with the location of any concept at different time points will preclude an accurate assessment of true movement over time.

A consideration of measurement theory and the two studies reported here would indicate that larger numbers of observations – more constructs and elements – tend to compensate for deficiencies in categorical data. But the major conclusion to be drawn from the examples presented is the commonsense observation that refined analysis will not adequately substitute for unrefined measurement.

References

Beail, N. (1984). Consensus grids: what about the variance? *British Journal of Medical Psychology* 57, 193–5.

Cary, J. W. and Holmes, W. E. (1982). Relationships between farmers' goals and farm adjustment strategies: some empirics of a multivariate approach. *Australian Journal of Agricultural Economics* 26, 114–30.

Fransella, F. and Bannister, D. (1977). *A Manual for Repertory Grid Technique*. London: Academic Press.

Jaffe, E. D. and Nebenzahl, I. D. (1984). Alternative questionnaire formats for country image studies. *Journal of Marketing Research* 21, 463–71.

Pope, M. L. and Keen, T. R. (1981). *Personal Construct Psychology and Education*. London: Academic Press.

Rathod, P. (1981). Methods of analysis of repgrid data. In H. Bonarius, R. Holland and S. Rosenberg (eds.), *Personal Construct Psychology: Recent Advances in Theory and Practice*. London: Macmillan.

Shaw, M. L. G. (ed.) (1981). *Recent Advances in Personal Construct Technology*. London: Academic Press.

Slater, P. (1972). *The Measurement of Intrapersonal Space by Grid Technique*, Vol. 2: *Dimensions of Intrapersonal Space*. London: Wiley.

Torgerson, W. S. (1958). *Theory and Method of Scaling*. New York: Wiley.

Woelfel, J. and Fink, E. L. (1980). *The Measurement of Communication Processes: Galileo Theory and Method*. New York: Academic Press.

Young, G. and Householder, A. (1938). Discussion of a set of points in terms of their mutual distances. *Psychometrica* 3, 19–22.