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The analysis of a repertory grid

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The problems of repertory grid analysis fall into two main groups: (i) general scaling problems; (ii) specific methods of the simplification of the grid data. Some problems of psychological scaling are considered including 'ranking' versus 'rating', equal interval assumption, and comparison of constructs. The grid analysis methods of principal component analysis, multidimensional scaling and cluster analysis are described briefly, whilst a hand-sorting cluster-type method is demonstrated. Methods for processing pairs and groups of grids are also considered.

This paper reviews some of the general issues in psychological scaling with reference to repertory grids, including the problems of the use of scales by individuals and the interpretation of the meaning of these data by the psychologist. Three methods of multivariate analysis are considered for their applicability to repertory grid data, followed by more detail about the FOCUS based programs using clustering techniques.

A repertory grid or 'construction matrix' is essentially a two-way classification of a topic in terms of the entities involved and their properties. In Kelly's own terms

> it expresses one's own finite system of cross-references between the personal observations he has made and the personal constructs he has erected. (Kelly, 1965, pp. 290–291)

The problems of the analysis of the grid fall into two major categories – methods for exhibiting pattern and structure in the grid responses, and methods for psychological scaling in general. The general problem is dealt with first.

General scaling problems

Much work has been carried out in the psychological field on how people perceive and use scales (for example, Pollack, 1953; Helson, 1964) but the question now is the extent of the relevance of these findings to the scaling used in forming constructs. In past studies using grids, two techniques have been commonly used for assigning each element a position on a construct. These are 'ranking' and 'rating'. In the ranking method, the elements are rank-ordered from the emergent (left-hand) pole, by successively choosing elements in terms of their similarity with this pole, not necessarily with reference to the implicit (right-hand) pole. Humphreys gives an example of the danger in the use of this method, where the nature of the implicit pole can affect the ranking obtained. This is the consideration of the two elements 'girlfriend' and 'girlfriend's mother', with respect to the emergent pole of the construct which is 'cool'.

> It is easy to imagine a situation where 'girlfriend' would be ranked more 'cool' than her mother when the implicit pole is 'uncool', but at the same time less 'cool' than her mother when the implicit pole is 'warm'. (Humphreys, 1973, pp. 3–4)

The simplest form of the rating method is in the use of dichotomous constructs where an element associated with one pole is assigned an 'x', or with the other an 'o'. An example is given in Fig. 1 where the element set comprises the family members and the teacher of an adolescent.

More often a five- or seven-point scale is used to give greater discrimination and so enable a more sensitive positioning of the elements on the constructs.

The rating method has in the past been used in about 70 per cent of grid studies compared with 30 per cent using ranking. Some study has been made as to which method

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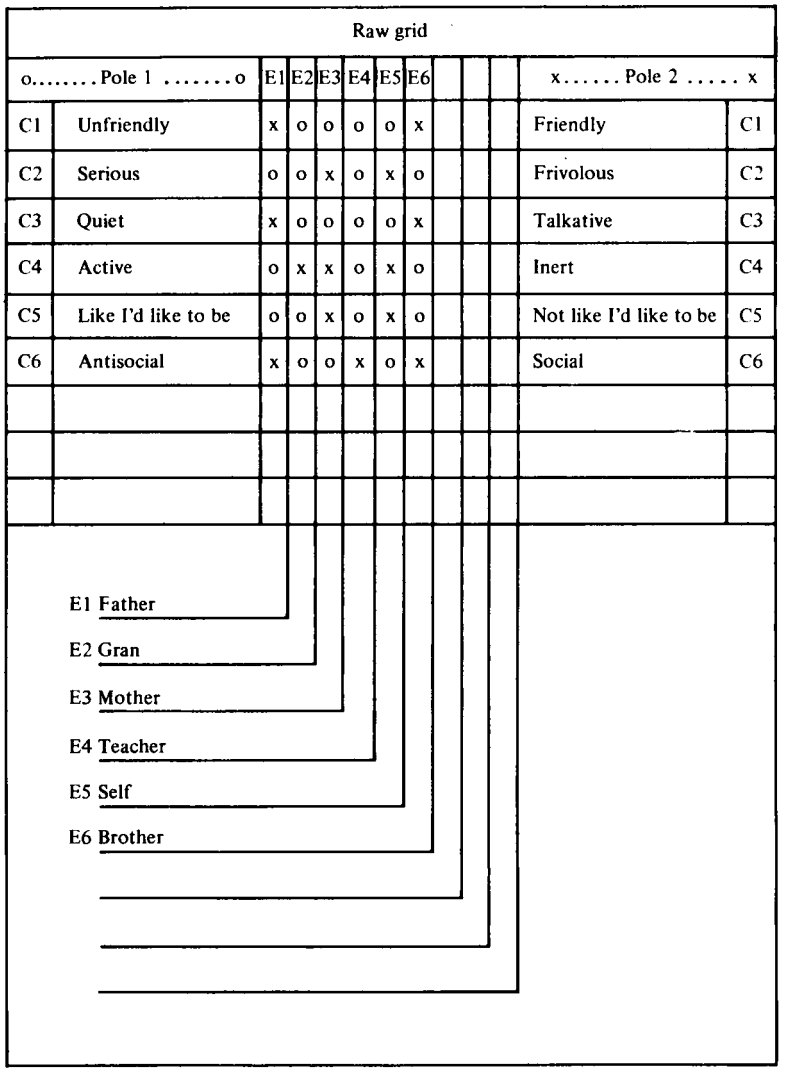

Figure 1. A raw grid for family relationships.

is to be preferred, but the results can be summed up by Mair & Boyd (1967) who say that either may be appropriate in any particular experimental context. Rating scales generally may have different attributes which are summarized in Table 1.

Table 1. Properties of scales

	Properties			
Scale	Labels	Order	Equal intervals	Absolute zero
Nominal	×			
Ordinal	×	×		
Interval	×	×	×	
Ratio	×	×	×	×

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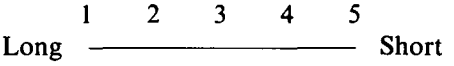
What can be assumed about a construct on which a five-point rating scale is used from 1 at the left pole to 5 at the right pole? For example:



Some eliciters give verbal labels to the points such as:

1 very long
2 quite long
3 neither long nor short
4 quite short
5 very short

but is this imposing the eliciter's construct system on the subject? If so, one must be aware of this, and not interpret the results as being those of the subject, but rather a composite of the subject and the eliciter. This is a general problem in the interpretation of psychological data. Statistical techniques are available to investigate the equal-interval assumption in data rated along a dimension, but such techniques require that the same data be replicated many times (cf. Messick, 1957). This is an impossible condition to satisfy with a single elicited grid.

The range-finder technique (Daisley, 1971) is relevant here. This involves splitting all the elements on to the left or right pole; each group is then split again, the two centre groups being joined into one so that any early bad judgement can be overcome at the next stage. The process is repeated until both the construct and the scale are felt to be well defined. A modification of this process seems desirable to cope with elements which initially seem to be outside the range of the scale. At each stage an extra group is formed of those elements which seem to be unplaced and these elements are collected together into a group of 'not-applicables'. These may then be considered again on the more accurate scale, and some will be placed on the second or third iteration. The number of iterations required for any element may give an indication of how certain the subject feels about both the position of the element on the scale, and the coherence of the particular element. Any that remain after this are either not coherent entities (for example 'son' was used in two ways 'son as I am now' and 'adolescent son' by one subject) or truly 'not applicables' which help in determining the construct range. A dyadic grid (Ryle & Lunghi, 1970) of relationships as elements, if elicited concurrently, will shed some light on the implicit associations being made.

The problems become more acute when comparison is made between two constructs. Formally, constructs may be regarded as mathematical functions and one of the requirements in the definition of equality between functions is that they should have the same range. In practice, for constructs a compromise must be made. When eliciting constructs, the eliciter should be aware of signs indicating that the ranges of the constructs are different (such as most of the ratings being towards one end of the scale, or a predominance of central values), and take this into account when the grid is analysed. If the elicitee is asked for constructs which apply to all the elements, and the ratings are not 'lop-sided' (Bannister & Mair, 1968) then it is reasonable to assume that the requirement for a constant range is satisfied.

Simplification of grid data

The second problem is then to describe the pattern of variability in the grid responses. Humphreys sums this up:

> A major aim of most descriptive analyses in current use is to *simplify* the data represented in the grid as much as possible, while still accounting for the major part of

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> the variability in that data. It is also desirable that the analysis should display the results of simplification in a way that is both understandable and communicatable. (Humphreys, 1973, p. 6)

The traditional methods of grid analysis have been the D^2 (non-metric) method of factor analysis, (G. A. Kelly, 1955; Osgood *et al.*, 1957; J. V. Kelly, 1964; Bonarius, 1965), other methods of factor analysis both metric and non-metric (Cronbach, 1955; Coombs, 1964), principal component analysis (Slater, 1964, 1967, 1972), and multidimensional scaling, (Torgerson, 1958, Shepard, 1962; Kruskal, 1964; Coombs, 1964). These three methods are quite closely related, the main differences being in the number of dimensions extracted and the form of representation used. The use of the term 'non-metric' indicates that only ordinal properties of the data are assumed (Shepard *et al.*, 1972). There is some feeling that factor analysis is inappropriate (Slater, 1969). More recently cluster analysis has been used to identify patterning in the grid responses (Rosenberg, 1976). All these methods use matrices of similarities between the elements and between the constructs which are usually calculated using either similarity or distance measures. Similarity coefficients are generally used with binary data, otherwise the most commonly used is the product moment correlation coefficient. This measure has been criticized by many authors, Everitt (1974, p. 53) gives an example to show its inadequacy. Distance measures or metrics are also used, usually cases of the mathematical functions known as Minkowski metrics (Everitt, 1974).

Principal component analysis

This method consists of the replacement of the construct (or element) correlation matrix with a matrix having the maximum values on the leading diagonal and all other values zero, if possible. This identifies the principal components of the matrix which may then be plotted geometrically as orthogonal axes. This method relies on the fact that most of the variability can often be expressed in two or perhaps three components, and that the meanings of the components may be interpreted from a component loading matrix. Slater's (1972) techniques are widely used to extract the principal components in a grid. These use product moment correlation to produce the correlation matrices. Other methods also produce interesting and helpful results such as Tucker's (1963) core matrix relating the element and construct principal components, and Sammon's (1969) method for obtaining a two-dimensional representation of the data.

Multidimensional scaling

This is somewhat similar to principal component analysis in the initial transformation of the correlation matrix. The results are produced in the form of a set of two-dimensional configurations, each increasing the number of dimensions represented. The aim is to find the solution in as few dimensions as possible. The usual procedure for determining minimal dimensionality is first to obtain a one-dimensional solution, a two-dimensional solution, and so on up to some number of dimensions considered more than sufficient for the input data. For a grid with n constructs, this would be $n-1$ dimensions. A badness-of-fit measure, termed 'stress', is also calculated for each solution. The stress measure is essentially a normalized sum of squared residuals, 0 per cent being a perfect fit. Stress necessarily decreases or remains constant with increasing dimensionality as the fit improves, the rate of change of stress determining the optimal dimensionality. The most commonly used computer method is KYST (Kruskal *et al.*, 1973).

Cluster analysis

Cluster analysis is one of the more recent techniques used to analyse repertory grids. There are several types available, those most commonly used being hierarchical methods in which

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the groups formed are themselves formed into groups at a higher level; optimization-partitioning techniques in which some criterion for partitioning is optimized by allowing entries to be reconsidered thus correcting any mismatching; density methods where highly dense areas are sought to identify the groups; and clumping techniques in which an entity may be a member of more than one group.

The FOCUS method

One of the first methods used for repertory grids was the hierarchical method of McQuitty (1960), later developed into the 'focus' technique (Shaw & Thomas, 1978) (so denoted to suggest the use of an optical instrument to sharpen and clarify the pattern of responses in the grid). The algorithm is similar to the single linkage or nearest neighbour hierarchical method, in that it systematically reorders the rows of constructs and columns of elements to put like with like. The correlation matrices are calculated from a distance measure and the FOCUS algorithm was developed especially to make the patterning of the grid responses meaningful to the subject and suitable for talking him back through the connections partially made visible during the elicitation process. This is done in two ways. Although it is carefully validated mathematically, and complex subroutines are used to wind up and unwind the clusters as they are identified, the computer output is very simple. The maximum given is: the two matrices of element and construct matching scores, the focused grid and the two trees of clusters which are fitted onto the grid. The focused grid is clearly only a rearrangement of the raw grid responses, and hence the mathematics is almost hidden. The subject is therefore not disturbed by 'mathematical magic' being performed behind his back, or factors produced out of a hat. He can see his own actual grid responses on display. Secondly, the rows of constructs and columns of elements have been sorted out in such a way as to show the least change between any two adjacent rows or columns down and across the grid, together with the diagrams showing the extent of the similarity of adjacent lines. The grid analysis results can then be fed back to the elicitee, and lend themselves easily to self-interpretation by the user of the grid.

Focusing by hand

A simple example is given to demonstrate a hand analysis based on the FOCUS computer program. (It is not easy to carry out principal component analysis or multidimensional scaling by hand; a computer is essential.) Although much of the structure, is exhibited in this case, it is somewhat more difficult if a five- or seven-point rating scale (or ranking) is used, and some of the patterning may be overlooked.

Using the grid of Fig. 1, two steps to focusing are shown. In its raw form the repertory grid presents the elements in the order in which they were originally named and the constructs in the order in which they were elicited. But this is not the best form of presentation from which to abstract the full meaning of the responses. Visual inspection of the elements reveals that father and brother have been similarly assigned to the constructs. Mother and self have also been assigned similar responses. The meaning of the grid is partly clarified by reordering the elements.

Now visual inspection reveals that constructs C2 and C5 contain a similar pattern of responses and that C1 and C3 are also the same. Thus reordering of the constructs produces Fig. 3.

Finally, since the constructs are bipolar, the pole descriptions and the associated 'o' and 'x' codings can be reversed without changing the underlying meaning in the responses. Thus, in the example, constructs 1, 3 and 6 can be reversed showing E6 and E1 as having all 'o's and E3 and E5 as having all 'x's.

The focused grid shows that the elicitee sees mother and self as inert, quiet, antisocial

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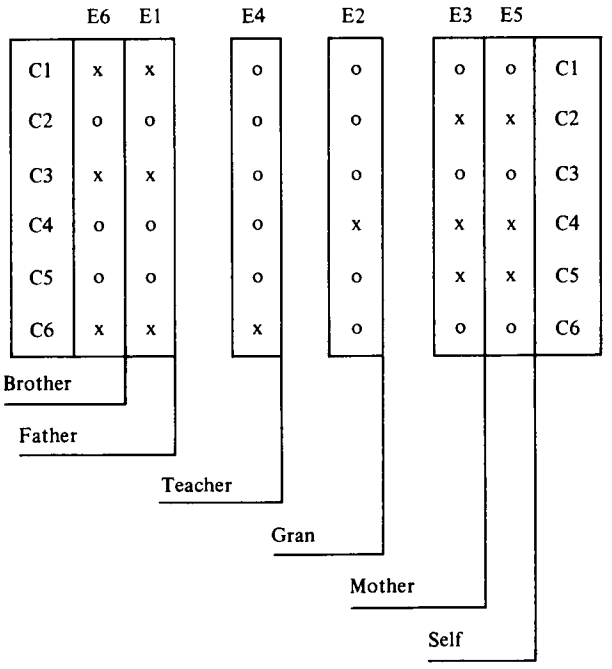

Figure 2. Sorting the elements.

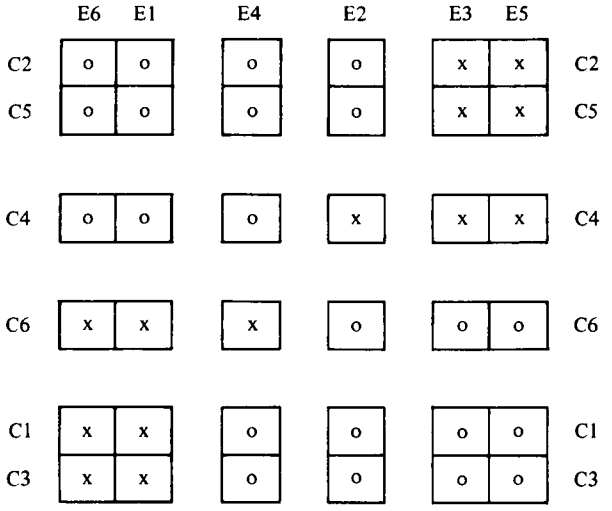

Figure 3. Sorting the constructs.

and unfriendly, also frivolous and not like he'd like to be. On the other hand he sees his father and brother as talkative, social and friendly, also active and serious as he would wish to be. He has mixed views of his teacher and gran. But the grid reveals more about the elicitee than it does about the members of the family. It shows the terms in which he thinks and feels about the people, and how his different thoughts and feelings relate to each other. On the evidence of these six elements he feels that:

(a) Frivolous people are not as he would like to be but rather he would like to be serious.
(b) Inert people tend to be antisocial whereas social people are active.

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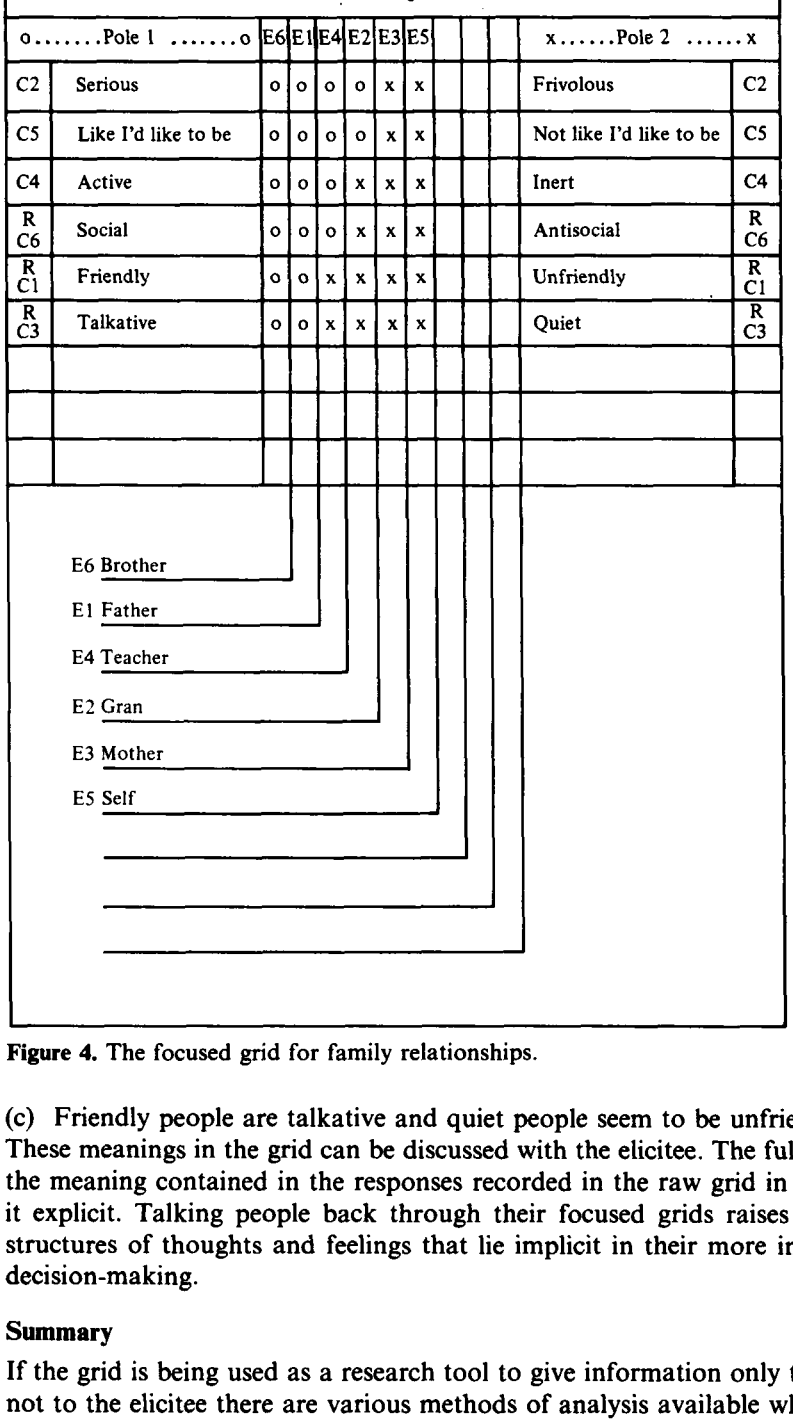

Figure 4. The focused grid for family relationships.

(c) Friendly people are talkative and quiet people seem to be unfriendly.

These meanings in the grid can be discussed with the elicitee. The fully focused grid presents the meaning contained in the responses recorded in the raw grid in such a way as to make it explicit. Talking people back through their focused grids raises their awareness of the structures of thoughts and feelings that lie implicit in their more intuitive judgements and decision-making.

Summary

If the grid is being used as a research tool to give information only to the experimenter and not to the elicitee there are various methods of analysis available which will indicate the major factors underlying the responses, the extent to which these represent all the responses, and the relative positions of the constructs and elements with respect to this particular representation. Many experimenters have difficulty understanding the computer output. Many try to see through the eyes of the elicitee to name the factors in such a way

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as to incorporate as much of the relative positioning of the elements and constructs as possible. This is very difficult even with experience and practice. If the constructs have been normalized the verbal pole labels will no longer have the same meanings as those intended by the elicitee; the results therefore begin to represent an intermingling of the construct systems of both the elicitee and the experimenter. For example, if the pole names were 'cares about me' and 'doesn't care at all' and only ratings from left to centre are used, the right pole becomes in effect 'not so caring'.

This can partly be overcome by consulting the elicitee about how the factors or components can be named, but this can too easily result in the elicitee being made to feel bewildered and inadequate as he peruses factor loadings, angular distances and other mathematical mysteries. If the purpose of the grid is awareness-raising then the feedback of the principal components can be difficult. This is due to the form of the results which leads to the distancing of the person from his original grid. To comply with the spirit of psychologists such as Rogers and Kelly one must aim to interpret the results as little as possible, leaving this to the subject.

The focused grid was developed in answer to this problem, producing results in a form which allows the person to reflect on his patterns of meaning by retaining the original responses, grouped into clusters. The purpose of the feedback is to offer to the elicitee a pattern of the groupings of the elements on the constructs and the constructs on the elements. The ensuing conversation is an exploration of the personal meaning attached to these groupings by the elicitee. The validity of the analysis is measured only in terms of a subjective feeling of personal significance. Keen (1977) quotes the test–retest reliability on grids as being less than 0·2 and not significant when feedback is provided but significant at the 0·1 level when feedback is withheld. This clearly indicates that some reconstruction takes place as a result of the feedback process.

Pairs and groups

The programs described in this section are based on the FOCUS algorithm for extracting similarities, and concern the processing of more than one grid. Two grids which have the same element and construct labels can be compared with respect to the similar or different uses of these names by examining the differences in the patterning in each grid. MINUS is a program which identifies the difference and similarity between the two grids by superimposing one on the other. The resulting matrix is then focused to identify those constructs and elements which are being used in the same way. A measure of overlap is produced based on the matching scores algorithm which is given as a percentage of the possible similarity in the two patterns of responses. Those elements and constructs which remain unchanged on the two occasions may be part of a person's core structure. An alternative approach to identifying core constructs and elements is used in the CORE program. In order to measure change in the two dimensions of elements and constructs, each is held constant alternatively whilst change in the other is calculated. Therefore the two grids are processed by successively deleting the element which has moved the most on all the constructs, and the construct which has most changed all the elements. The resulting unchanged diminished grid is termed the 'core' grid. If the two grids are elicited from different people, the CORE analysis can be used to identify the extent of understanding and agreement between them. It is especially useful in the 'exchange grids' procedure (Shaw, 1979).

Although CORE offers new potential for investigating understanding between two people, it is not always appropriate to use the same element or construct names. Elements are more easily shared than constructs since they are representative of the common problem under discussion. Individual grids are elicited therefore, and submitted to the SOCIOGRIDS

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program. SOCIOGRIDS analyses a set of repertory grids elicited from a small group of people who share a set of elements (Thomas *et al.*, 1976). It focuses the grids singly and in pairs – the PAIRS algorithm being used to compute the measure of similarity between the two grids – and produces a set of 'socionets' showing the shared construing within the group. A 'mode grid' of the most highly matched constructs is extracted and then focused. Each grid is focused with this mode grid and a measure of overlap of each with the mode grid is calculated. This technique is used for investigating the relative positions of the members of the group, and the content of the sharing of terms and values. Each individual set of personal constructs represents that person's thoughts and feelings about the universe of discourse. As these are expressions of the person's construct system played out in this domain, ideas are tapped which the individual is bringing to bear on the subject perhaps without his own knowledge. If some of these ideas are shared by other members of the group, it may benefit all the participants to have them made explicit.

A sequence of mode grids can be used to chart changes in group construing over a period of time, which has special application in evaluating educational or industrial training courses. Using the socionets, an individual's position in the group can be monitored over time by noting the links which are made and the subgroups the individual joins on different occasions. Together, the socionets and the mode grid can be used to investigate how misunderstanding has grown in a group, and how group performance is influenced by the levels of agreement and understanding which exist, and which can be achieved.

Conclusion

The repertory grid is a useful and developing technology for eliciting and developing personal models of the world, and helping each individual to be more effective in his aim to become a 'personal scientist'. Kelly's view of a personal scientist was someone who classifies, categorizes and builds theories about his world, testing these against his personal experience, reviewing and revising his theories in order to anticipate events and act effectively. The repertory grid may be used as a vehicle for a person, group, or organization to move from where he is to where he wants to be; or just to make the individual more aware of his own processes and how they relate to those of the group. Whichever method is used to analyse the grid, it should be chosen for its suitability for the problem, for the form and content of the results, and their applicability to the general problem or area of investigation. Various methods of grid analysis have been described briefly, but references are given to works which describe and use them more fully.

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