Computers and People Series

edited by B.R. Gaines

Recent Advances in Personal Construct Technology

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Mildred L.G. Shaw

Academic Press

A Subsidiary of Harcourt Brace Jovanovich, Publishers

London New York Toronto Sydney San Francisco

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Edited by
Mildred L. G. Shaw
Middlesex Polytechnic England

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ACADEMIC PRESS
A Subsidiary of Harcourt Brace Jovanovich, Publishers
London • New York • Toronto • Sydney • San Francisco

ACADEMIC PRESS INC. (LONDON) LTD.
24–28 Oval Road
London NW1

United States Edition published by
ACADEMIC PRESS INC.
111 Fifth Avenue
New York, New York 10003

British Library Cataloguing in Publication Data

Recent advances in personal construct technology
1. Personality
I. Shaw, M. L. G.
155.2 BF698

ISBN 0–12–639260–9

Printed by J. W. Arrowsmith Ltd.
Bristol BS3 2NT

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Preface

This book is based on the special issue of the International Journal of Man-Machine Studies on Personal Construct Technology published in July 1980, together with three related papers from the Journal and a new introductory paper. The theme is applications of George Kelly's personal construct theory and the technologies on which these may be based, particularly the interactive computer. There has been a tremendous growth of interest in these topics during the past five years and this book covers a wide range of techniques for use by management consultants, psychologists and computer scientists. Although work in the area of personal construct theory and the associated repertory grid technique originated in clinical psychology it has diversified into many other areas. In particular, this technique has been used to extract subjective data in situations where before it had not been possible: in industrial training, quality control, management development, self-organized learning and self-counselling. Recently, personal construct techniques have been recognized as a basis for building expert systems on a computer.

The wide range of possible applications of personal construct technology stems from the extremely general foundations adopted by Kelly. Central to his psychology is the view of man acting as a *personal scientist*: that is, forming hypotheses about the world, testing them against his experience, and revising them through using them to anticipate events in the world. Many people who have used interactive repertory grid programs and had this process made explicit to them experienced surprise or even shock when they realise the basis of some of their assumptions. I hope that the papers in this book will encourage others to explore the techniques in their own areas of interest.

The papers included here are a selection from recent work in personal construct technology ranging from a survey of current usage to reports of advanced research. Jack Adams-Webber has written a personal appreciation of Kelly and his work as a special introduction to this book. This is a first hand account based on his personal experience as a student with Kelly at Ohio State University and later at Brandeis. Few people now interested in his work knew Kelly personally or heard him lecture; the insight into him as a person is valuable in assimilating his published work.

Mark Easterby-Smith gives a comprehensive introduction to the elicitation and analysis of a repertory grid which is an ideal starting point for someone who has never used such techniques. Mildred Shaw describes extensions to the use of repertory grids through collaborative methods by means of which a group of people can find levels of understanding and agreement. Philip Boxer also extends the method to incorporate computer assisted reflective learning in a management context. Terry Keen and Richard Bell describe a technique for eliciting constructs which avoids some of the difficulties of the more commonly used 'triad' method. Estelle Phillips' paper gives a fascinating example of the use of grids in the area of the subjective judgement of the research skills of Ph.D. students; this topic in particular highlights the use of these techniques in an area where there is much academic concern and controversy. Maureen Pope and Mildred Shaw highlight a similar area of concern—education and learning—and indicate how personal construct technology can help educationalists of differing schools to achieve their differing objectives.

The papers by Patrick Slater, and by Mildred Shaw and Cliff McKnight are concerned with the reconciliation of differing perspectives: Slater examines conflict situations and suggests a technique for resolving the difficulty often encountered of people who have to work together whilst refusing to see the point of view of the other side; and Shaw and McKnight look at the individual's construing of other points of view. Ranulph Glanville's paper describes a technique which is related to the grid in that it extracts from a person his construct structure and model of the topic.

The last four papers by Brian Gaines and Mildred Shaw, Fred Eshragh, Richard Bell and Terry Keen, and Chris Leach are more technical in nature. Gaines and Shaw examine the foundations of the repertory grid in personal construct theory and suggest an alternative basis for its analysis based on logical foundations which lead to a new asymmetric grid analysis program ENTAIL. Eshragh applies the technique to subjective decision-making and gives examples of a program doing this. Bell and Keen use statistical techniques to derive a new measure of cognitive complexity, and Leach describes methods of cluster analysis for repertory grids, and in particular a new cluster analytic method of processing grids.

In conclusion, I would like to thank all the contributers and Simon Hasleton who was at the time visiting Patrick Slater, not only for their contributions but also for their comments on all the papers. I am grateful to Brian Gaines for his helpful advice during the preparation of this book. I am also grateful to John Senders who was at Brandeis with Kelly, Maslow and Adams-Webber for discussing with me his interactions with these people; the overall impression is one of Kelly quietly getting on with his work and having little to say about it in public.

May 1981

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Contents

George A. Kelly as scientist-professional: an appreciation

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When Mildred Shaw invited me to write an introductory piece for this volume, she indicated that she thought that many persons whose interest in personal construct psychology developed out of their study of Kelly's published works might like to know more about how he himself implemented this theoretical system in psychotherapy and research. She suggested this topic in the knowledge that during my graduate training at both Ohio State University and Brandeis University I had considerable contact with Kelly, not only as my teacher in several courses, but also as my psychotherapy supervisor, and later, as chairman of my Ph.D. thesis committee. The following account presents some of my personal impressions of how he typically operated as a professional psychologist and a scientist. In retrospect, I believe that Kelly was successful in integrating these two roles within the conceptual framework of personal construct psychology.

I first became acquainted with Kelly's approach to psychology when I was assigned to him as my first psychotherapy supervisor. This was before I had made any serious attempt to find out what personal construct theory was all about. It is probably relevant that at the time I was a dedicated student of social learning theory, engaged in research on "generalized expectancies concerning the locus of control of reinforcement" (Adams-Webber, 1969). I was convinced that this was the most scientific approach to human psychology. On the other hand, anyone who has tried to understand another human being in terms of the principles of learning might well appreciate why, in anticipation of my first experience in psychotherapy, I was open to the consideration of alternative constructions.

Initially, I had specifically requested Kelly as a supervisor because of his outstanding reputation as a professional psychologist. Frankly, at that point, I did not care what kind of scientist he might be, since I regarded my professional and scientific training as entirely separate spheres of activity. Indeed, I had begun to suspect on the basis of my previous clinical experience in psychiatric hospitals that professional status and scientific integrity might be correlated negatively.

Thus, my experience with Kelly in the context of psychotherapy supervision was the original source of my interest in personal construct theory as a system. I became interested in it for pragmatic reasons. Specifically, Kelly showed me, as a novice therapist, how I could use this theory to structure my interaction with clients, thereby reducing somewhat my own confusion and anxiety while undertaking a new adventure. Kelly believed that formal theory should not stand between therapist and client. Therefore, he did not try to impose his own system on therapists in training. He insisted, however, that they develop a coherent formulation of the client's problem and a related plan for "treatment". I found personal construct theory more useful for this purpose than other theories I had studied, possibly because I had never given much thought to the clinical applications of the latter.

Kelly also introduced me to some very useful "techniques". Later, I discovered that most of these techniques relate logically to the basic principles of personal construct theory. In retrospect, this hardly seems surprising, since there is a sense in which personal construct theory evolved out of "personal construct technology" more or less in the way that "form follows function". Kelly's initial formulation of his system began as an attempt to develop a coherent rationale for all the working assumptions and concrete procedures which he had invented during twenty-five years of clinical experience. When he finally stated all the basic principles of this "model", Kelly found that he had constructed a general theory of how people go about interpreting and anticipating their personal experiences.

It is interesting that Carl Rogers' client-centered theory seems to have evolved in a somewhat similar manner, especially since Rogers was a predecessor of Kelly's as director of training in clinical psychology at Ohio State University. Some graduate students had contact with both Kelly and Rogers, although they were not both there at the same time. Rogers' (1961) account of the origins of client-centered theory contains some striking parallels to Kelly's (1969) "Autobiography of a Theory".

Abraham Maslow, like Kelly, developed his own "psychology of science" (Maslow, 1966). Since, for a brief period, Maslow and Kelly were colleagues in the same department of psychology at Brandeis, the question of whether they had much influence on each other's thinking is an interesting one. As a graduate student at Brandeis, I enjoyed extensive contact with both of them. It was a small department allowing close relations between students and faculty. Personally, I could never find much common ground in their respective approaches to psychological inquiry beyond the fact that they both emphasized the personal experiences of individuals as the primary focus of concern. Others who were there at that time may have discovered more similarities. In any event, most of us welcomed the opportunity to learn from both of them.

Following are some examples of "principles of psychotherapy" that I picked up on an informal basis from Kelly in supervision which derive their rationale from the basic assumptions of personal construct theory. One of the most important of these is the "credulous approach", which can be summarized in terms of Kelly's maxim: "if you want to find out what is wrong in a client's life, ask him—he may tell you." On the other hand, Kelly also warned that the client might not respond in terms of the dimensions the therapist used to pose the question. In order to begin to understand the client's view of the problem, the therapist must become familiar with the personal axes of reference which the client ordinarily uses in interpreting her/his own experience. It follows that whatever "professional" constructs the therapist employs, for example, *guilt*, s/he should try to use them to subsume the personal constructs of the client.

> Now a good therapist must frequently, among other things be accepting of his client. He should attempt to anticipate events in the way the client anticipates them. He should try to employ the client's vocabulary in thinking about the issues which the client sees himself as facing. He should give words the meanings that the client gives them, rather than the meanings the dictionary gives them, or the personal and professional meanings he has himself customarily given them. (Kelly, 1955, p. 587)

Eventually, I found out that this approach involves a direct application of Kelly's theoretical definition of *role* as a course of activity carried out in the light of one's understanding of another person's point of view (cf. Kelly, 1970). Subsequently, this conception of role proved useful in my laboratory research (Adams-Webber, *et al.*, 1972); however, I had learned first how Kelly implemented this principle in establishing a role relationship between therapist and client. In fact, it was my clinical experience that was the original source of my theoretical interest in Kelly's definition of role and my most important resource when I began to investigate it "scientifically" in controlled experiments.

Kelly also suggested that it is especially important to listen carefully to what the client specifically does *not* say, that is, the unspoken contrast to what s/he does assert. Suppose that the client were to state that "all people are basically good" (to use one of Kelly's, 1955, own examples). What could be the contrast to universal goodness? Perhaps, there was a time in the past when the client thought exactly the opposite. Alternatively, s/he may fear that s/he now is on the verge of doing something which is evil. It could also be the case that, whereas the client has always tried to emulate Pollyanna, striving to find the good in everyone, her/his parents are quite cynical.

This useful "technique" also involves the implementation of an abstract principle. Specifically, Kelly's (1955) *dichotomy corollary* implies, among other things, that the contrast pole of any construct (e.g. *bad*) is as important in understanding its meaning as the nomal pole (e.g. *good*). This idea, which I first encountered in the idiographic context of individual psychotherapy as a facet of "technique" has become the central focus of my current theoretical and experimental research (Adams-Webber, in press).

Perhaps the most important principle to which Kelly introduced me in therapy supervision is "constructive alternativism". He argued that the fundamental postulate of personal construct theory and its various corollaries can be derived logically from this one assumption (Kelly, 1969). It asserts that events do not reveal their meanings to us directly, but rather they are subject to as many alternative ways of construing them as we ourselves can invent (Kelly, 1955). This does not imply, according to Kelly, that one interpretation of an event is just as good as any other. Some ways of construing it are likely to prove more useful than others in the long run for predicting and controlling it.

Kelly showed me an important "practical" application of this principle while I was trying to function as a clinical psychologist in a psychiatric hospital and having my troubles with my "senior" medical colleagues. He pointed out that from the standpoint of constructive alternativism it is not necessary to become embroiled in debates concerning whether the cause of a client's problem is "really" psychological or physiological in nature. We can set aside the "mind-body" distinction and consider the more important *functional* issue of what is the most useful way of construing the problem from the point of view of future prediction and control. As separate conceptual frameworks, or "construct systems", psychology and physiology provide the bases of alternative constructions of the same events, one of which may prove more useful for predicting and controlling them eventually.

Meanwhile, we should consider the consequences to the client of trying to pre-empt the question in terms of a psychological construction, and neglecting to obtain a physiological construction from a suitably qualified professional, or *vice versa*. A dramatic illustration is the case of an asthmatic girl who died during an attack after her therapist, who was a psychologist, advised the medical staff to withhold her medications because they reinforced her dependent behaviour. In short, Kelly found ways of using his abstract theoretical principles in resolving practical issues with potentially important consequences for the client, such as disputes over professional jurisdication.

Kelly viewed psychotherapy in general, and his "fixed-role" therapy in particular (cf. Adams-Webber, 1981), as an investigative project designed to elucidate problems in the client's life without resorting to applied psychology. He saw both client and therapist as engaged in scientific inquiry. The client is the principal investigator, although s/he may be somewhat reluctant at first to commit her/himself to this role. The therapist more or less fulfills the role of a research supervisor. A course of therapy is planned as a programme of active experimentation in which the therapist assists the client in constructing hypotheses and testing them. The independent variable which the client tries to control systematically in these experiments is his/her own behaviour. This is in sharp contrast to "scientific behaviourism" in which the client's behaviour is regarded as the dependent variable which is controlled by manipulating external stimulus conditions.

Thus, the way in which Kelly employed personal construct theory to structure the process of psychotherapy was as a sort of "psychology of science" to help guide therapist and client in the conduct of personally meaningful inquiry. The goal was that the client, with some methodological assistance from the therapist (Landfield, 1971), would develop into a more effective "personal scientist" (to use Mildred Shaw's excellent term) (Shaw, 1980).

At a more superordinate level, Kelly regarded all scientific inquiry as a personal undertaking. He thought that it is their human nature that makes scientists what they are. "The notion of *man-the-scientist* is a particular abstraction of all mankind and not a concrete classification of particular men (Kelly, 1955, p. 4)." I have tried to convey some of my own impressions of how Kelly himself was able to use his model of "man as scientist" in structuring the interaction between client and therapist. He used it in a very similar way in guiding the research of his thesis students. In his "Autobiography of a Theory", Kelly (1969) offers a detailed examination of the formal parallels between how he operated as a therapist and as a thesis supervisor. The following account presents some concrete examples from my own experience.

Kelly and all his current research students used to meet as a group every week for two hours. During the four years in which I participated in this "research team", I became quite familiar with the ways in which Kelly used personal construct theory to guide formal psychological inquiry. Probably, I understood his research strategy better than I would have without my previous experience with him as a therapy supervisor.

There was no specific agenda of "relevant" topics to which Kelly and his students addressed their investigations. Theory-testing in the strict sense of logically deriving hypotheses from formal principles and operationalizing them in terms of the same limited conceptual framework was far from the minds of most of us. Although we all were more or less acquainted with Kelly's own theoretical orientation, he consistently encouraged us to develop and test the implications of our own constructions. This fact may provide part of the answer to a question which many students of personal construct theory, who have had no direct contact with its author, find extremely puzzling: why is it that so few of Kelly's former students have pursued issues in personal construct theory in their own research.

This is less surprising when we consider that many of his students showed no great interest in this theory when they were actually members of Kelly's research team. The attitude of many members of this group toward Kelly and personal construct theory was that they liked the singer, but not the song. In my own experience, I was never able to separate the two. My role relationship with Kelly as research student and advisor was based primarily upon my attempts to understand his theory and use it as a general framework within which I could elaborate some of my own ideas. Part of the reason for this may have been that I came into clinical psychology from an undergraduate background in philosophy and I was used to working on problems within the context of a larger system. In any event, as a former student of Kelly who is still pursuing the implications of personal construct theory in may own research, I belong to a small minority.

Kelly never looked for disciples. He certainly did not discourage interest in his own theory on the part of his students. In fact, he always seemed to appreciate it, but he never insisted on it. The basic ground of unity underlying the diverse theoretical interests of Kelly's research students, insofar as one existed, was a kind of diffuse constructive alternativism—not the fundamental postulate and its corollaries. Kelly succeeded in creating an atmosphere of extraordinary intellectual freedom at our weekly meetings. This was condusive to the kind of discussions which follow wherever the argument leads rather than returning again and again to the same old assumptions.

Before joining the research team, most of us had completed graduate courses in research design and statistical analysis; however, few of us had much experience in the "pre fixed design" phase of psychological research. It was at this stage in the development of our research projects that Kelly provided the most guidance and assistance.

Whenever a new member joined the team, s/he was asked to briefly summarize her/his own research interests. Afterward, s/he invariably would be confronted by Kelly himself with some version of the following question: "What events in your own personal experience do you think led to your concern with these issues?" This question was predicated on a number of assumptions which were shared, at least implicitly, by most of us who remained on the team for any length of time.

The first of these was that the development of any psychological problem, no matter how abstract it appears in its final form, begins with a personal construction of events. This construction is only one of many possible ways of interpreting those events. All this follows directly from Kelly's principle of constructive alternativism. He also derived from this principle the notion that research students, as well as clients in psychotherapy, could profit from examining their personal conceptual biases, making these more explicit, and communicating them to others to get "feedback" from a variety of different perspectives. It always turned out that the members of this research team, at any point in time, entertained a wide variety of contrasting assumptions about human nature, the philosophy of science, the purpose of psychological research, what kind of issues were most important in the field, etc. Therefore, they usually provided a new member, or visitor, with a lively and convincing illustration of constructive alternativism.

Secondly, Kelly maintained that all psychological inquiry should relate at some level to issues in the lives of individual persons. I cannot recall anyone's conducting research with animals, but I doubt that Kelly would have minded as long as s/he made some connection with human experience. He did not encourage his students, however, to concern themselves with formal problems which were not related to issues in people's lives. Thus, in a sense, Kelly was a firm advocate of "ecological validity" long before this concept became fashionable.

Thirdly, Kelly held that a psychologist's own fund of personal and clinical experience with an issue is often her/his most important resource at the beginning of an investigation, usually far more useful than a review of published work on the topic. Almost all Ph.D. theses include a chapter containing a review of the relevant literature. Theses directed by Kelly typically also include a kind of personal research diary which gives an account of the author's own experience with the problem from its first inception of the beginning of formal experimentation. This autobiographical history of the research venture usually provides a more accurate impression of where the ideas came from and how they developed than the conventional "formal derivation of hypotheses" from theory, which is often window dressing added after all experimentation is complete and the final results are known.

Fourthly, the process of reflecting upon one's own personal experience with an issue helps to free one's thinking from the "scientist"/"subject" dichotomy that pervades so much psychological research. Kelly made similar assumptions about the nature of formal scientific inquiry and the everyday experience of the people whom psychologists hope to understand.

> But science is itself a form of human behavior, and a pretty important one, at that. Why, then, should we feel compelled to use one set of parameters when we describe *man-the-scientist* and another set when we describe *man-the-laboratory subject*? (Kelly, 1969, p. 97).

Kelly liked to point out that many textbooks in psychology contain two theories of behaviour. The first is a highly coherent account of the scientific activities of psychologists themselves. The second is a very fragmented description of the behaviour of ordinary people and other organisms. Kelly thought that the first theory provided a more promising starting point for developing a general theory of human psychology.

If, in the initial stages of formulating a research problem, we can see some of its implications in terms of our own personal experience, we will be more likely to treat the people who participate in our experiments as active collaborators with their own anticipations, rather than as passive "subjects" to be manipulated by the experimenter. For instance, Kelly was opposed to deceiving subjects, or even unnecessarily keeping them in the dark concerning the purpose of an investigation. If those who help us in our research know what question we are asking, they will be in a better position to assist us as collaborators in the task of making sense of their experiences in our laboratories.

Kelly also had some definite notions about formal research designs. He greatly favoured the use of repeated observations with the same individuals over a period of time, for example, at different stages of a decision cycle—circumspection, pre-emption and control. He showed little enthusiasm for the traditional "individual differences" study comparing the mean scores of different groups—say depressives, anxiety neurotics and normal controls—on some standard instrument. On the other hand, during the period that I was a member of his research team, I never once heard Kelly dictate to a student what s/he should or should not do in the name of science. No matter how vague or implausible a student's initial proposal for a research project, Kelly's advice was always to "get on with it". He encouraged us to pursue any personally meaningful question and not to worry about whether what we were doing was really scientific. If it works, he would say, then science will probably claim it.

It is all too easy for a graduate student in clinical psychology to develop two separate subsystems of constructs without much connection between them. The range of convenience of one subsystem is more or less confined to clinical or "professional" work. The range of convenience of the other tends to be restricted to "scientific" pursuits. Both are important forms of psychological inquiry; however, the psychologist who is unable to integrate these two subsystems may experience considerable role conflict (in the Kellian sense), and may resolve this eventually by abandoning either the professional or the scientific perspective. Nonetheless, it is not necessary to view *scientist-professional* as a dichotomous distinction. As an individual, Kelly was able to devise a system of constructs within the framework of which he successfully integrated these two contexts of psychological inquiry.

References

ADAMS-WEBBER, J. (1969). Generalized expectancies concerning the locus of control of reinforcements and the perception of moral sanctions. *British Journal of Social and Clinical Psychology*, **8**, 340–343.

ADAMS-WEBBER, J. (1981). Fixed role therapy. In *Handbook of Innovative Psychotherapies* (CORSINI, R., Ed.). New York: Wiley.

ADAMS-WEBBER, J. (in press). Assimilation and contrast in personal judgements. In *Systems of Personal Constructs* (MANCUSO J. and ADAMS-WEBBER, J. Eds.). New York: Praeger Scientific Press.

ADAMS-WEBBER, J., SCHWENKER, B. & BARBEAU, D. (1972). Personal constructs and the perception of individual differences. *Canadian Journal of Behavioural Science*, **4**, 218–224.

KELLY, G. A. (1955). *The Psychology of Personal Constructs*. New York: Norton.

KELLY, G. A. (1969). The autobiography of a theory. In *Clinical Psychology and Personality: The Selected Papers of George Kelly* (MAHER, B. A., Ed.). New York: Wiley.

KELLY, G. A. (1970). A brief introduction to personal construct theory. In *Perspectives in Personal Construct Theory* (BANNISTER, D., Ed.). London: Academic Press.

LANDFIELD, A. W. (1971). *Personal Construct Systems in Psychotherapy*. Chicago: Rand McNally.

MASLOW, A. H. (1966). *The Psychology of Science*. New York: Harper & Row.

ROGERS, C. (1961). *On Becoming a Person*. Boston: Houghton Mifflin.

SHAW, M. L. G. (1980). *On Becoming a Personal Scientist*. London: Academic Press.

The design, analysis and interpretation of repertory grids

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This paper is intended for those with some knowledge of the repertory grid technique who would like to experiment for themselves with new forms of grid. It is argued that because the technique is quite powerful and the basic principles of its design are easy to grasp there is some danger in it being used inappropriately. Inappropriate applications may be harmful both to those involved directly, and to the general reputation of the technique itself. The paper therefore surveys a range of alternatives in the design of grids, and discusses the factors that are important to consider in these cases. But even if a design has been produced which is inherently "good", any applications based on this will be of doubtful value unless prior thought has been given to the availability of analytic techniques, and to the means of interpretation of the results. Hence the paper outlines a number of approaches to the analysis of grids (both manual and computer based), and it also illustrates the possible process of interpretation in a number of cases.

1. Introduction

Repertory grids are seductive. They are so because they promise accurate measurement of subtle perceptions, while being based on a technique which appears to be quite simple. They are also extremely easy to modify and adapt, which has encouraged many people to design and develop their own applications.

Those who have gained some experience in using grids will realize that it is not all as easy as it appears to be. The design and elicitation of a grid can be a very delicate matter requiring considerable skill and sensitivity. It is quite easy to design new forms of grid, but unless these are done appropriately they will not yield any useful information. In addition the design should also take account of the way the grid is to be interpreted, and the forms of analysis that are available.

There is a great deal of advice about these points in books which are aimed mainly at clinical applications (Bannister & Fransella, 1971; Fransella & Bannister, 1977, are among the best), but there is a surprising shortage of advice about applications outside the clinical field. This paper aims to fill that gap by making some basic and practical points about the design and interpretation of non-clinical grids. It is aimed at those people who are generally familiar with the components of a grid and the basic elicitation process, but who would like to experiment with their own designs. (I have described a range of possible applications, and some of the theoretical ideas underlying grids in an earlier publication: Easterby-Smith, 1980.) The paper is divided into two sections, considering design, and analysis and interpretation, respectively. It is illustrated where possible by examples from management development and training in organizations.

2. Alternative designs of grids

The repertory grid is undoubtedly a very fertile instrument. It allows great flexibility in design and application, and this flexibility is often very stimulating for the user. But it does have its dangers, and therefore this section will begin by examining some of the areas of flexibility in the design before discussing some of the do's and don't's that have been gleaned from practical experience with the technique.

A full repertory grid contains three components: "elements", which define the material upon which the grid will be based; "constructs", which are the ways that the subject is grouping and differentiating between the elements; and a "linking mechanism" which can show how each element is being assessed on each construct. It is in the different permutations within these areas that the main flexibility in designing a grid lies.

2.1. ELEMENTS

We shall begin with a summary of the main ways that the elements may be determined. Since the remainder of the grid will be derived from these elements, appropriate selection is obviously critical. The elements determine the focus of the grid and it is important that this is as *specific* as possible.

There are two general points to emphasize about element specification. Firstly the elements should be *homogeneous*. That is, they should all be drawn from the same category. Acceptable categories might be: "people who have a critical influence on my performance at work"; "my subordinates"; "the main activities in my job"; "jobs that I might apply for"; "types of training event"; "Nineteenth-century painters", etc. In most cases it is not acceptable to mix categories in a set of elements, as for example in, "Subordinate *A*, Subordinate *B*, My Boss, Attending Meetings, Talking on the Phone . . .". The reason for this is that the constructs that are generated from elements in one category are not likely to be applicable to those in another category. For example, the construct *honest–dishonest* could be applied to most people, but it would be difficult to describe "attending meetings" in terms of *honest* versus *dishonest*—certainly not without some stretch of the imagination.

Secondly, the elements should provide *representative coverage* of the area to be investigated. A grid about "significant people in my life" which did not include spouse or parents might be rather suspect. Similarly it is important to include good and bad dimensions, and one way of doing this is to include contrasting pairs of elements: "A Colleague You Like"; "A Colleague You Dislike"; "A Manager Likely to Get On"; "A Manager Not Likely To Get On". There are however some problems with this approach since it can influence the nature of constructs elicited towards the dimension chosen for contrasting the elements. Also many managers find it very difficult to name someone whom they dislike, so this could be softened to "Someone You Like Less".

In addition, if the same grid is to be completed by a group of people, it is important to ensure that all the people are able to relate directly to the elements specified: a research chemist asked to name five subordinates may not actually have any subordinates; a graduate trainee asked to rate his reactions to "Chairing Meetings" may have no direct experience of chairing meetings, whereas the Works Manager may base his ratings on the very direct experience of chairing two meetings a day for the last five years.

What is the ideal *number of elements* in a grid? For industrial applications the answer is: as few as you can get away with. If the grid is to be analysed on a computer, it is probably unwise to have less than six or seven because below that number the analysis can easily become distorted, but it should be possible to provide adequate coverage of the chosen topic with no more than twelve elements. Most of the grids suggested by Kelly, and those used by clinical psychologists, have 15–25 elements—but this is rarely necessary for organizational applications.

Generating elements

In the discussion above, it has been assumed that elements will normally be indicated by the investigator† in the form of role descriptions (i.e. "An Effective Subordinate"), and the person completing the grid then fits a real person to that role description ("Ah yes, John Stewart is an effective subordinate"). Thereafter he thinks of John Stewart specifically when he generates his constructs and when he provides ratings of "An Effective Subordinate" in the rest of the grid. It is perhaps worth re-emphasizing the point that unless the subject can think of a *specific* person or instance to fit the role description, the results of the grid will not mean much. This method of providing role descriptions is one of several ways of establishing elements, which vary from those where the subject has a great deal of choice, to those where he has virtually no choice. The various methods are summarized below:

(i) *Supply elements*: a list of named individuals is provided; several specific incidents on a videotape are pinpointed; six abstract paintings are displayed, etc.
(ii) *Provide role or situation descriptions*: a number of types of people at work are specified or some typical experiences at work are indicated. The subject must provide his own specific examples to fit these general descriptions.
(iii) *Define a "pool"*: the subject is asked to "name five subordinates", to "name three effective managers", or to "list five leisure activities that you have indulged in", etc.
(iv) *Elicit through discussion*: investigator and subject discuss the topic of interest. The investigator may have prepared a number of prompts to help the subject, but as a result of this discussion, a list of specific elements is drawn up jointly.

2.2. CONSTRUCTS

Strictly, there need be no difference between the nature of the constructs and the elements employed in a grid. This stems from wider definitions of what constitutes a grid, for example, Bannister & Mair (1968, p. 136) define one as:

> "Any form of sorting task which allows for the assessment of relationships which yields these primary data in matrix form."

However, it makes the design and interpretation of grids somewhat easier if a distinction is made, and one such distinction is to think of *elements* as being the objects of people's thoughts, and *constructs* as the qualities that people attribute to these objects (Smith, 1978).

Generating constructs

There are four distinct methods of generating constructs in a grid, and a few minor variations and combinations.

† For purposes of clarity the person administering the grid will be called the *investigator*, and the person completing the grid, the *subject*. With a self-administered grid, the same person will be both subject and investigator.

Element	Comment
1. Talking with your boss 2. Writing reports 3. Attending a course	Rather woolly; not specific enough
4. Motivation 5. Leadership 6. Charisma	These terms are rather vague, and drawn from a different category to the job activities in 1–3
7. The Marketing Manager	Does subject know him?
8. Your boss	This may be too sensitive
9. A high performing subordinate 10. A low performing subordinate 11. A colleague difficult to get on with 12. A colleague easy to get on with	Fine, although the evaluative aspect might influence the types of constructs that emerge subsequently
13. Yourself now 14. Yourself as you hope you will be at the end of this development programme	Useful. But the grid is getting unnecessarily large by this stage
15. An activity that you spend a lot of time on 16. An activity which is central to your performance in this job	Good activity-type elements

FIG. 1. Examples of good and bad elements. (These might have been generated by any of the above methods.)

(i) The quickest way to generate constructs is simply to *supply* them. Thus a participant on an interpersonal skills course may be asked to rate the other members of the group (elements) on such dimensions as *listens well–doesn't seem to hear*; *supportive of new ideas–inhibits new ideas*, etc. In effect the grid is being used as a semantic differential (Osgood, Suci & Tannenbaum, 1957) since the subject is not being asked to contribute *his own* descriptions of these elements. However this approach can be useful in some situations *provided that* the constructs supplied are known to be representative of the ones that the subject would have produced spontaneously, and he already has an adequate understanding of what they mean.

(ii) The classical approach to generating constructs is to *elicit them from triads*. This method involves selecting groups of three elements (triads) from the full list of elements, and the subject is then invited to say in what way two of the elements are *alike* and in what way the third element is *different* from the other two. This procedure is intended to produce two contrasting poles for the construct, although it is sometimes suggested that the poles should be opposites. However, the difficulty with requesting "opposites" is that it tends to produce logical opposites rather than opposites in meaning. The *logical* opposite of *ambitious* is *not ambitious*; but the subject may think of the *real* opposite of *ambitious* as being *does not trample on colleagues*. Clearly, the latter, contrasting, approach indicates far more about the meaning of the construct.

The *selection of triads* may also affect the final grid. Successive triads should either be chosen on a genuinely random basis or by the investigator deciding which combinations will bring out the greatest contrast in the elements available. It is important that elements are given roughly equal chances of appearing in triads, otherwise some elements will tend to dominate the type of constructs being produced, thus distorting the overall grid. Also the elements in successive triads should be changed quite rapidly (don't repeat two elements in successive triads), otherwise people may have considerable difficulty in thinking of new constructs.

It is also possible to elicit constructs from *dyads* (see Keen & Bell, 1980). This method is normally used when the subject finds it too hard to generate constructs from triads—and it is quite common when the elements themselves are complex, such as relationships between pairs of people. Two elements are selected at a time and the subject is asked to say whether they are alike or different, and what it is that makes them alike or different. The main reason for *not* using this method in preference to triading is that the resulting constructs tend to incorporate logical opposites, rather than opposites of meaning (as discussed above).

Another variant on the triading theme is to *combine* elicited and supplied constructs in a grid. Providing that the supplied constructs are selected carefully this can be a useful way of focussing on some important dimension to be investigated. (In screeening managers as potential members of assessment centre panels, the construct *effective-not effective* is supplied in addition to a list of constructs elicited about junior managers.) If several constructs are supplied, this will enable direct comparisons to be made between individuals' grids which are otherwise totally different. However, there are two caveats when mixing constructs. Firstly, the supplied constructs should be given *after* constructs have been elicited, otherwise they will influence the type of construct that the subject thinks of for himself. Secondly, the investigator must be confident that the supplied constructs will be used as diversely as the elicited constructs. If the supplied constructs group too closely together (say five constructs are supplied and they are all closely linked around the dimension *good performance–bad performance*) they will dominate the other constructs in the grid and make it appear that the whole grid revolves around this dimension.

(iii) Some people criticize the grid for being unnecessarily verbal. This criticism is not justified when the grid is designed correctly. Verbal labels are not particularly important, indeed it is possible to design totally *non-verbal* grids based on *card sorts.* The elements are written onto cards and the subject is asked to sort the cards into piles of similar cards. He may then be asked to say what the similarities are within each pile. Alternatively, the position of each card is noted and the subject is simply asked to repeat the procedure using some other basis for sorting—thus a normal matrix can be built up which enables element relationships to be examined (this procecure has been used with children and dumb patients). This approach may be of particular use when the elements are things such as *objets d'art,* or manufactured products which are being subjected to quality control inspection.

(iv) The final method of construct generation to be considered here is known as *laddering,* and this is normally used in conjunction with one of the other methods. Thus a few constructs may have been elicited by triading, and the subject is then asked to look more closely at the first construct. He is asked which end of the construct is preferable and *why* this is so. For example in a grid based on people the construct *extrovert–introvert* might have emerged. The subject indicates that he would prefer to be "extrovert".

The conversation between subject and investigator might then proceed as follows:

Investigator: "Why would you prefer to be *extrovert*?"
Subject: "Because people *respect* 'extroverts'; introverts are *disregarded*".

Investigator: "Why is it important to be 'respected'?"
Subject: "Because this indicates that you are a *valuable* person; people who are 'disregarded' are *worthless* . . . ."

In this way a series of new constructs can be generated from any of the original constructs, and they will tend to be increasingly fundamental (superordinate) for the person producing them.

In this process the question *why* tends to produce constructs of greater generality, while the question *what* or *how* tends to produce more specific constructs. With the above example the investigator might have asked the subject if he could say a little about *what* he meant by *extrovert* or *introvert.* To which the answer might have been *keen to talk to strangers* against *avoids talking to strangers.* This construct is at a lower level of generality and would therefore be described as "subordinate" to the original construct.

Types of constructs

Three main types of construct can be distinguished according to how they are *used.* For example, the construct *trade unionist–company type* might be used in such a way that this was the *only* construct that a line manager could apply to members of Trades Unions. Where he regards them as *nothing but* trades unionists, he is using the construct in a *pre-emptive* manner. This rather extreme usage might occur when the manager is particularly angry or frustrated; however the *constellatory* manner of using a construct is more common. This occurs in stereotyped thinking where the manager will immediately associate the trade unionist with a number of other labels: *uncooperative, reactionary, short sighted,* etc. He probably will not differentiate clearly between these other constructs and will tend to apply them to anyone who is a trade unionist, whether he knows him as an individual or not. The third usage of a construct is in the *propositional* manner. Here the manager might be saying to himself: since we are currently faced with a recognition claim from ASTMS it is convenient to think of some people as if they were *trade unionists* and others as if they were *company types*—but in normal working routine this is a distinction which is of little practical value.

In many cases, the usage of a construct can be inferred without much ambiguity from its labels. There are a number of construct labels which it is wise to *avoid.* Taking as an example some constructs about people:

situational constructs (*lives in Brighton*; *has two children*) are not useful unless they are seen as important indicators of people's natures;
excessively "permeable" constructs may be of limited value because they can be applied to almost everybody (*is a man–is a woman*), and therefore tell you little new;
excessively "impermeable" constructs are applicable to a tiny range of people (*copes well with weightlessness–panics under weightless conditions*), and therefore have limited general value;
vague or superficial constructs (*is OK–not so good*) rarely add much to a grid;
constructs generated by the role title (*is an effective manager–not so effective*) would add little when they are simply repeating something which is already incorporated into the selection of elements for the grid.

In all these cases, the investigator should try to probe further by asking questions such as: "In what way does living in Brighton have an effect on him?" or "Can you say a little more about what makes these two managers effective, and this one less effective?". Wherever possible, the investigator should push towards evaluative constructs which express how the subject feels towards the various elements he is considering.

Social context of elicitation

With the exception of introspective grids, all applications of the repertory grid involve one person trying to persuade another to cooperate with his wishes. This is true whether the subject is following written instructions, completing a grid in a classroom in parallel with a number of other students oı having a one-to-one discussion with the investigator. Clinical psychologists may disregard the power relationship between themselves and their clients, because the client is essentially a captive audience who is there to be helped—and who probably accepts the authority of the psychologist without question. This is patently not the case with managers. The problem is not so much one of biasing the results—since repertory grids are very difficult to fake, even by people who understand how they work; it is more one of maintaining goodwill and cooperation. Murphy (1978) has found this to be a major problem when using the grid to help internal organizational consultants examine their roles. After a successful initial administration of the grid to these consultants, they showed signs of losing patience on a subsequent occasion. On reflection this seemed to be because the consultants needed to feel in control of the overall process and able to accept or reject any particular methodologies. The investigator should offer himself as a resource to the client rather than as a trainer or researcher—thus involving the client in the design of any application in order to develop the maximum ownership.

This places the investigator in something of a dilemma. On one hand the grid requires some skill and experience in order to use it to full advantage; on the other hand managers on the receiving end will rapidly become alienated from the process unless they can be involved in its design from the start. Given the normal constraints of time and resources, perhaps the best solution to this is to ensure that applications of the grid are as short as possible, and that the design is as simple as possible—so that managers can understand how conclusions are drawn from the raw data. With regard to the number of constructs that are elicited, these should again be as few as possible (eight constructs should be enough)—particularly if it is hoped to obtain grid data on a second occasion from the same people.

2.3. LINKING CONSTRUCTS TO ELEMENTS

Certain applications of the grid stop short of establishing links between constructs and elements. Although this may be appropriate where the labels of constructs are being elicited simply as an input to a group discussion it does miss an important part of the grid—because it is *the way the construct is used* in relation to the elements which indicates the *meaning* of the labels given to each *pole*. The normal method is via some kind of rating scale. These rating scales can be seen in a continuum ranging from dichotomous scoring to ranking, involving increasingly fine differentiations in each case as indicated below.

Dichotomizing:

√	√	×	√	×	×

If the element is closest to the left pole of construct, place a tick in the relevant box; if closest to the right pole, a cross. To avoid skewed distributions, subjects are sometimes instructed to make sure that the elements are divided equally between ticks and crosses on each construct.

Ratings:

3	2	5	3	4	3

The above case would be seen as a rating scale with only 2 points; more normally rating scales would have 5, 7 or 11 points. It is assumed that the points on the scale indicate equal gradiations between the two poles of the construct. The choice of the number of points is largely a matter of personal preference. (I prefer 5 or 7 points.)

Ranking:

4	5	3	1	2	6

If there are, say six elements in a grid then all the elements are put in order from 1 to 6 on each construct. This is exactly the same as a 6-point rating scale where no score may be repeated.

Dichotomous (2-point) scales tend to be more useful if hand analysis is required, or if the grid is to be used for discussion purposes. Ratings on 5- or 7-point scales allow for slightly more discrimination on each construct and it may be quite important to allow the opportunity to make these finer distinctions. Ranking scales provide very much greater discrimination, but this may force the subject to indicate differences between elements where he really sees no difference. There is also a tendency for the rankings to be made in relation to the emergent pole of the construct, without taking much account of the contrasting (latent) pole. This means that the construct may only be partially incorporated in the grid—and this is increasingly likely if there are more than eight or ten elements.

The choice between rating and ranking methods depends largely on the purpose for which the grid is designed, but Shaw (1980) notes that about 70% of published studies use rating methods. One important aspect of rating scales is that they provide an opportunity to check whether the elements really are in the *range of convenience* of all the constructs—and thus if the grid has been constructed correctly. Although the subject should be asked to complete ratings for all elements on all constructs, he can also place a mark, such as an asterisk, in any box where he feels that the construct is not really applicable to that element. If many of the elements are felt to lie outside the range of convenience of the constructs there may be a fundamental fault in the design of the grid.

2.4. SOME ADVICE

This section has provided an overview of the main alternatives in the design of grids. Several more may be found in some of the clinically-oriented writings on repertory grids, and there is constant innovation amongst users. For those wishing to devise their own designs I would give three pieces of advice:

(i) Keep the grid small. A grid containing ten elements and ten constructs may take two hours to complete. Larger grids may take substantially more time.
(ii) Ensure that the elements are specified clearly and are well understood.
(iii) As far as possible, avoid putting words into the subject's mouth, either through the design of the grid or through the way constructs are elicited.

3. Analysis and interpretation of grids

It is very attractive to think that we now have a technique that can quantify the subjective data from which human judgements and decisions are taken. The potential for quantification tends to emphasize the numbers in the grid, and these can exert an almost mesmeric influence upon the would-be psychologist-statistician. This has led to two common misconceptions about the grid: firstly, that it cannot be analysed adequately without a computer; secondly, that if a computer analysis is conducted this will provide answers to any questions asked about the grid.

In answer to the first point, it is quite possible to draw conclusions from the raw matrix of a grid without conducting any computations at all. In some circumstances it is not even necessary to complete the matrix (as when construct elicitation is used as an input to group discussion); therefore there will be no figures to work on anyway. Where a rough analysis is required, and the grid is reasonably small, it is possible to conduct this manually. It is only necessary to use computers when the grid is large, when time constraints are limited, or when there is a need for very precise measurement. In this part of the paper I shall begin by discussing manual analysis of grids before illustrating the range of computer analyses available.

With regard to the second misconception it should be noted that the interpretation of grid data is very much an art and *not* a technology. In grid terms the investigator must develop a personal construct system which allows him to relate to the grid that has been produced, and the purpose for whch it was designed. This will only develop as he gains experience in finding that the meaning he attributes to the grid is similar to the meaning that was intended by the person who produced it. In cases where the subject plays a major part in interpreting the grid a sophisticated computer analysis may provide a barrier between his initial grid and the subsequent output, and therefore will make it very difficult to interpret this output at all.

3.1. TECHNIQUES FOR MANUAL ANALYSIS

A certain amount may be understood from a grid simply by looking at the ratings of the elements on the constructs. By inspecting the rows and columns of the matrix, and examining the relationships between constructs and elements, it is possible to infer quite a lot, but this process can be helped by various forms of analysis which rearrange or summarize the grid data in order to make them more comprehensible. When the grid is relatively small, and particularly when it is important for the analysed output to be linked closely to the original grid, manual techniques are very suitable.

Several forms of manual analysis will be presented below based on the simple grid illustrated in Fig. 2. The elements at the top are those selected by a female manager who completed the grid. The five constructs written down the sides of the grid were derived from triads of these elements. In the matrix each element is given a tick (√) if it is judged to fall at the left-hand end of a construct, and a cross (×) if it is judged to fall at the right-hand end.

	(√)	1 "Myself"	2 "Boss"	3 "Husband"	4 "Best Friend"	5 "Person Disliked"	(×)
A	*driving*	√	√	• √	• √	• ×	*easy-going*
B	*moving*	• √	• ×	√	• √	×	*"has-been"*
C	*rigid*	×	• √	• ×	×	• ×	*open*
D	*intellectual*	• √	• √	√	• ×	×	*non-intellectual*
E	*critical*	• ×	×	• ×	√	• √	*accepting*

FIG. 2. Simple introspective repertory grid. (A dot in a cell of the matrix indicates that the element above was one of the "triad" that produced the construct for that row.)

One approach to the analysis of this grid is to rearrange the rows and columns so that similar constructs are positioned close to each other, and then so that similar elements are positioned close to each other. In practice this means reversing the directions of constructs C and D, which changes the crosses into ticks and vice versa. Construct A is moved to a position between C and D since it is quite closely related to each of them (only one cell is different in each case). Similarly the elements and their respective columns are rearranged so that the numbers of matches between adjacent columns are maximized. The resulting grid is shown in Fig. 3.

	(√)	4 "Best Friend"	1 "Myself"	3 "Husband"	2 "Boss"	5 "Person Disliked"	(×)
B	*moving*	×	√	√	√	×	*"has been"*
C	*open*	×	√	√	√	×	*rigid*
A	*driving*	√	√	√	√	×	*easy going*
D	*intellectual*	√	√	√	×	×	*non-intellectual*
E	*accepting*	√	√	√	×	×	*critical*

FIG. 3. A focussed grid.

This process is known as *focusing* and forms the basis of the cluster analysis programs developed by Shaw & Thomas (1978). A more extensive illustration of how to focus a grid manually is provided by Shaw (1980).

Correlation matrices can also be obtained for elements and constructs simply by counting the number of matches in pairs of columns or rows. Thus for elements 1 and 2 there are three matches and two mismatches. The number 3 will therefore be entered into the appropriate cell of the matrix (see Fig. 4). There are five matches between elements 1 and 3, three matches between elements 1 and 4, and so on.

Elements	2	3	4	5
1 "Myself"	3	5	3	0
2 "Boss"		3	1	2
3 "Husband"			3	0
4 "Best Friend"				2
5 "Person Disliked"				

FIG. 4. Correlation matrix for elements.

From this matrix it is possible to see at a glance how close the various elements are described as being to each other (5 being total similarity, 0 being no similarity).

The correlation matrix for the constructs is shown in Fig. 5, based on exactly the same scoring method.

Constructs	B	C	D	E
A (*driving*)	4	1	4	1
B (*moving*)		0	3	2
C (*rigid*)			2	3
D (*intellectual*)				0
E (*critical*)				

FIG. 5. Correlation matrix for constructs.

One point to remember here is that the constructs are bipolar and therefore a score of 5 would be a score of 0 if the poles were reversed. Hence a low correlation is indicated by scores in the middle (2 or 3).

Up to this point, nothing has been said about interpretation of this grid, and one might be tempted to ask whether focusing, or the extraction of correlation matrices, adds anything to what might be deduced from looking directly at the ratings in the original grid shown in Fig. 2. The answer is that they add nothing new, but they make it easier to identify the patterns that are already there. Thus by looking at the columns in Fig. 3, it is immediately obvious that the ratings for "Myself" and "Husband" are identical on all five constructs, and that "Person Disliked" was different in all respects. These features are also apparent in the original grid (Fig. 2), but they are not quite so clear. In looking at the rows in the focussed grid it will be seen that two pairs of constructs are being used in the same ways. Thus, for example, in this grid *intellectual* people are always seen as *accepting*, and *non-intellectual* people are always seen as *critical*.

These associations can also be spotted quickly from the correlation matrices. Thus the high association between "Myself" and "Husband" (elements 1 and 3) is indicated by the correlation coefficient of 5 in Fig. 4. The low associations between these two elements and "Person Disliked" (element 5) are indicated by the 0's in the matrix.

The nature of these similarities and differences can also be examined by looking at the patterns in the grid. Thus the relationship between "Myself and "Boss" is indicated by comparing columns 1 and 2. She sees her boss as being similar to herself in all respects, except that she regards her boss as being *non-intellectual* and *critical* rather than *intellectual* and *accepting*. This is useful information if she wishes to develop a good working relationship with her boss since these dimensions are likely to be the touchy features in the relationship. Thus she might make allowance for the fact that she will tend to construe her boss's comments as *critical*, when in fact this may not have been her boss's intention. If she does judge this to be her boss's intention then she might choose to confront her boss with these specific perceptions.

If these results are to be put to constructive use, the focussed grid will be more helpful than the correlations in this case. Since the grid is intended as an introspective grid, the only person likely to gain any benefit from it is the person who completed it, and this will help her to spot the important parts.

As it is, the grid provides a representation of how she classifies some key people, but these perceptions could be extended by asking further questions around the grid. Thus our subject might explore whether she always saw *intellectual* people as being *accepting*. Is this always true, or can she think of any individuals whom she would consider to be *intellectual*, but *critical*? In this way further *elements* may be added to the grid. However, she might also wonder about the correlation between "Myself" and "Husband" over all five of these constructs. Does she always think of them in identical terms, or can she think of any other important constructs on which these two elements would be rated differently? If she can, she now has another construct in her grid—and she can continue this process of building up the grid and exploring specific avenues for as long as she likes.

In cases where grids are larger, the rating scales more extensive (i.e. 5 or 7 points), and a number of grids are completed concurrently, the correlation–type analysis becomes more useful (as a manual technique). Honey (1979) describes a number of applications using a partial analysis, and which require that the grid is designed closely around the topic to be examined. One application is intended to provide a pre–post course evaluation of a sales training course by looking at salesmen's perceptions of what differentiates effective from less effective salesmen.

For example, the trainee is asked to generate a number of constructs by triading, based on a set of six salesmen known personally to himself. He is then asked to rate all six salesmen on each construct, regarded as a 5-point scale, and also on an *additional* construct:

most effective–least effective.

Honey's interest is to identify how closely each of the constructs generated by the trainee are linked to this supplied construct of effectiveness. This is done by comparing the numbers in each row in turn with the numbers in the effectiveness construct. The difference between each pair of numbers is totalled for the full row, giving a difference score for that construct. The lower that score, the closer the construct to the dimension of effectiveness. This process is illustrated in Fig. 6.

	Salesmen (Elements)						Difference	
	1	2	3	4	5	6	score	Reversed
Construct 1	4	3	2	1	1	5	10	12
Construct 2	2	5	1	3	2	5	4	14
Construct 3	1	4	4	1	3	4	11	9
Most effective	3	5	1	4	2	3	Least effective	
Reversed effectiveness ratings	(3	1	5	2	4	3)		

FIG. 6. Simple correlations between elicited and supplied constructs.

The difference scores for each of the three constructs against the effectiveness construct are given at the right of Fig. 6. From this it appears that construct 2 is closest to the effectiveness dimension. According to the difference scores construct 1 would be the next closest, followed by construct 3. However, as noted above, these constructs (and their ratings) can be reversed without making any change to the meaning of the grid, and it is therefore advisable to check the difference scores under these circumstances. This is done by reversing the *effectiveness* scale (1 becomes 5, 2 becomes 4, etc.), and calculating the difference scores between this and each of the constructs. When this reversed difference score is less than the normal difference score, it should be adopted in the knowledge that it is the reversed construct which correlates with the effectiveness dimension. This means that construct 3 (reversed), with a difference score of 9, is slightly closer to the effectiveness dimension than construct 1, with a difference score of 10.

Honey's interpretation of these difference scores when evaluating the sales training course is interesting. The lower the average difference scores become over the period of the course, the better he regards it—indicating that the constructs generated at the end of the course cluster more closely around the dimension of effectiveness. This means that the salesmen are increasingly judging each other only in terms of effectiveness, and would be paying much less attention to, for example, the nature of their relationships.

The method described by Honey, for measuring the "distance" between two constructs is known as the Mean Absolute Difference (MAD) metric. The other kind of measure which is sometimes used is based on taking the difference between each pair of scores and *squaring* this difference, before taking an average for the complete row. The former, and variants on it, is most commonly adopted in manual forms of analysis; the latter, which is obviously more time-consuming, frequently forms the basis for computer analysis.

3.2. GENERAL COMPUTER ANALYSIS

The amount of work involved in analysing a grid increases rapidly with the size of the grid, and with the number of distance, and other measures, that are to be derived from it. This is why a number of computer packages have been designed to provide general analysis of almost any grid, providing statistics about most features of the grid. However, before considering computer analysis it is worth reminding the reader that this analysis does not *add* anything to the information available in a grid, nor does it provide any indication of the meaning of a grid; it simply reduces the amount of work required for interpretation by summarizing and condensing the data available. As Kelly himself put it:

> "Neither abstraction nor generalisation has ever been computerised.... What can be computerised... is the elimination of redundancy in a construction matrix. The resultant shrinkage in the matrix is sometimes mistaken for abstraction, or it appears to result in the expression of a great deal in relatively few terms. But the contribution the computer makes is to economy of the language employed, not to conceptualisation...." (Kelly, 1969, p. 290.)

There are two types of computer program specifically designed for repertory grid analysis and which are generally available in this country. These are the INGRID packages devised by Slater based on Principal Component Analysis (Slater, 1977) and the FOCUS program based on Cluster Analysis (Shaw & Thomas, 1978). In addition there are a number of standard packages which may be useful, although they are not designed for grids. These include the SPSS factor analytic options PA1 and PA2 (Nie, Hull, Jenkins, Steinbrenner & Bent, 1975) and multidimensional scaling methods (Shepard, Romney & Nerlove, 1972). The advantage of these latter packages is that they are more widely available on computer installations, and the multidimensional methods have the added distinction of not assuming that the ratings in the matrix are based on "interval" measurement. This means that they consider the *order* in which the elements fall on any particular construct, but not the numerical difference in the ratings between elements (whether absolute or squared). For example, those who support these "non-metric" analytic methods would point out that a gap of three points which occurs around the middle of a 7-point rating scale may be of the same significance as a gap of one point when both elements are near the end of a scale.

The main difference between Principal Components and Cluster Analysis is that the former searches out the greatest variation in the grid and imposes mathematical axes on these; the latter relies on building up a series of hierarchical groups based on the strongest associations in the matrix. An alternative way of considering what these two programs do is to imagine the stars of the sky spread out above one. These stars represent the *elements* in an individual's mental map—whether they be people, situations or objects. The purpose of the computer program is to find some way of describing all these points. The "Cluster Analysis" approach looks for the patterns in different parts of the sky and identifies the major groupings, like the constellations. Thus the structure of the map is built up gradually from various small groupings. The "Principal Components Analysis" approach contrasts with this by looking at the sky to identify the main overall dimensions. Thus it might note that the plane of the Milky Way is the most dominant dimension in the sky as viewed from the Earth, and it would then describe all other objects in terms of coordinates from this plane. Or it might decide that the Solar System or the Earth's axis, provided the most convenient frames of reference upon which to build a stellar map.

The question of whether Principal Components Analysis or Cluster Analysis provide the best form of analysis, has been the subject of considerable debate at a theoretical level (Rump, 1974; Slater, 1974). In practical terms, the INGRID program has the advantage of enabling a visual mapping of the elements and constructs to be made, and it also demonstrates the linkages between constructs and elements. The FOCUS program provides a very limited kind of map which does not give any explicit linkage between constructs and elements. However, it does have the great advantage over the highly sophisticated INGRID program, in that it is simple and the analysis process can be understood easily by whoever is using the grid. The choice between the two modes should depend on the context in which the grid is being used. FOCUS may be preferable in "operational" applications, where the grid is being completed and interpreted by the subject; INGRID may be preferable in "research" applications where some other person is attempting to interpret the grid data.

The forms of analysis produced by both of these programs will be illustrated below for the same grid.

An example

The following grid was produced by a Group Training Officer (G.T.O.) who was responsible for providing a training service to 12 small companies. He was employed collectively by these companies, but the role was overseen by the Industrial Training Board to which they were " in scope". The grid formed part of an evaluation study for a part-time development programme sponsored by the I.T.B. and lasting 12 months. It was completed before the start of the programme and was intended to give the Course Director an idea of how the G.T.O. saw certain key people at work, while providing a reference point for subsequent evaluation.

The grid, shown in Fig. 7, employed a role title list of eight elements (including three "self" elements), and constructs were generated by triading, using sets of elements indicated by the evaluator; constructs and elements were linked by ratings on a 7-point scale.

Cluster analysis

This grid, when processed through the FOCUS program, appears with constructs and elements rearranged as in Fig. 8.

It will be seen that in addition to constructs and elements being reordered, three constructs (C, D and F) have also been reversed. Additional data is also provided by the program which highlights two main clusters among the elements: 3, 5 and 7; 1 and 8.

The first cluster shows that the G.T.O. has high expectations of the course since he hopes to end up very similar to the "Progressive Manager" and the "Effective Trainer". The second cluster indicates how little he feels he has changed since he started his present hob.

Amongst the constructs, the first two clusters identified are constructs C and D, and constructs B and E. The first cluster shows that he sees extrovert people as being self-motivated; the second cluster shows that he considers those people who are committed to the I.T.B., rather than to companies in the industry, to be insensitive as opposed to sensitive. Thus the main patterns are identified and there is nothing mysterious in the way the parts of the grid are rearranged by FOCUS.

	Constructs			Elements ① "Myself as I am"	② "Training Adviser in I.T.B."	③ "A progressive Manager"	④ "A conservative Manager"	⑤ "An effective Trainer"	⑥ "A less effective Trainer"	⑦ "Myself expected at end of course"	⑧ "Me when I took this job"
A	*practical*	1–7	*academic*	5	5	4	3	4	4	3	5
B	*sensitive*	1–7	*insensitive*	2	5	3	1	3	6	2	3
C	*self motivated*	1–7	*not very self motivated*	5	3	2	6	2	1	2	4
D	*extrovert*	1–7	*introvert*	4	2	3	6	2	1	2	5
E	*committed to companies*	1–7	*committed to I.T.B.*	1	5	1	1	2	6	1	1
F	*worked hard*	1–7	*not needed to work hard*	3	2	1	5	2	2	1	3

FIG. 7. Pre-course grid for Group Training Officer (GTO).

Principal Component Analysis

In the case of INGRID, which uses Principal Component Analysis (Slater, 1977), there is a much larger leap between the initial grid and the final computer ouput. The program itself provides several pages of statistical output describing the mathematical structure of the grid. Coordinates are provided for all the constructs and elements, indicating where they are located in relation to the first two components (indicated by the broken axes in Fig. 9). These components are linked to the constructs and elements with the greatest variance (most extreme ratings) and it is assumed that they indicate the main dimensions in which the G.T.O. differentiates between these people at work. There are always additional components which may be extracted from the grid matrix, but these

				Elements							
				④	①	⑧	⑦	③	⑤	②	⑥
Constructs				"A conservative Manager"	"Myself as I am"	"Me when I took this job"	"Myself, expected at end of course"	"A progressive Manager"	"An effective Trainer"	"Training Officer in I.T.B."	"A less effective Trainer"
D	*introvert*	1–7	*extrovert*	2	4	3	6	5	6	6	7
C	*not very self-motivated*	1–7	*self motivated*	2	3	4	6	6	6	5	7
F	*not needed to work hard*	1–7	*worked hard*	3	5	5	7	7	6	6	6
A	*practical*	1–7	*academic*	3	5	5	3	4	4	5	4
B	*sensitive*	1–7	*insensitive*	1	2	3	2	3	3	5	6
E	*committed to companies*	1–7	*committed to I.T.B.*	1	1	1	1	1	2	5	6

FIG. 8. G.T.O.'s grid rearranged by FOCUS.

normally account for a minor part of the person's thoughts in a given area (8% in this case). Where the grid indicates a particularly sophisticated construct system (high *cognitive complexity*) these additional components may account for up to 30% of his thoughts and consequently, the two components that can be represented on a two-dimensional map will be explaining less than the total picture (Slater, 1977).

Although the components have high mathematical significance, they are not necessarily important when it comes to interpreting the mapping. Here it is more advisable to concentrate on the more concrete features of the map, the positions of constructs and elements, and the place to start is element 1 "Myself Now". It will be seen that the G.T.O. describes himself as *not very self-motivated* and *introverted*, he also sees himself as being quite similar to the "Conservative Manager". This might be contrasted with his view of the local "Training Adviser" who is seen to be *committed to the I.T.B.* and *insensitive*, or his view of the "Effective Trainer" and "Progressive Manager" who are seen as *self-motivated* and *hard working*. By drawing an arrow from element 1 to element 7, it is possible to represent his *expectations* of the forthcoming programme—

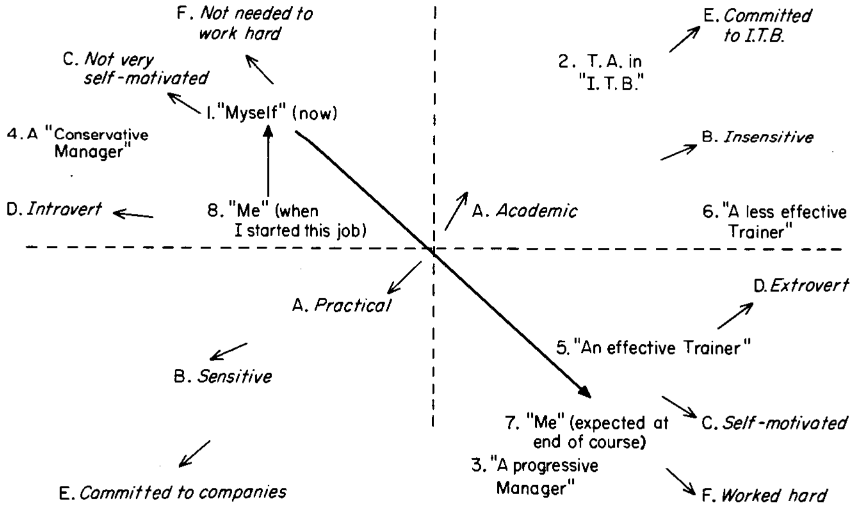

FIG. 9. Mapping of constructs and elements on first 2 components.

how he hopes he will have changed by the end. It will be seen that he hopes to move in the direction of being *self-motivated* and *hard working*, and that he hopes to end up as very similar to the person he describes as a "Progressive Manager". This expected change is in the opposite direction to how he sees himself having moved since he started his present job.

Since the constructs are bi-polar, the two ends of each occur on opposite sides of the origin. Those upon which the elements have been given more extreme ratings appear nearer the outside of this map. These are assumed to be key constructs in the individual's map, and it will be seen that the construct *committed to I.T.B.–committed to companies* emerges as most important. However, the direction of change expected from the development programme lies at right angles to this dimension, and therefore the G.T.O. does not anticipate any further movement towards either of these poles.

Further information can be gleaned from this grid by comparing contrasting pairs of elements. Thus the difference between "Conservative" and "Progressive Managers" is seen along (i.e. parallel to) the dimension *not very self-motivated–self-motivated*; on the other hand, the difference between an "Effective" and a "Less Than Effective" trainer is *construed* according to whether they are *committed to companies* or *committed to the I.T.B.*

The INGRID analysis of this grid was fed back to the Course Director, and the implications for him were as follows. Firstly, it gave him an idea of whether the participant (and individual grids were prepared for all participants) was expecting to change his approach and his view of himself as a result of the programme. Clearly this G.T.O. had rather high hopes from the programme, and he saw his needs in terms of becoming motivated—possibly through seeing new possibilities in his job. Secondly, it gave the Course Director an idea of how the G.T.O. classified others at work, and what were the important dimensions in these classifications. The *commitment* construct was obviously a sensitive one (and difficulties had arisen in this area on an earlier programme). The construct *academic–practical* might also have signalled difficulties, since this G.T.O., who was about to attend a development programme at a University Business School, hoped that he would become slightly more practical and *less* academic. This was another message which was heeded by the Course Director in attempting to reduce the theoretical inputs as much as possible in the programme.

Summary
In this particular case, it seems that the INGRID analysis provides richer data than FOCUS, although there is bound to be a credibility gap if the results of the former are fed back to the original informant. To some extent this can be lessened by talking the subject through the INGRID mapping so that he can see how it relates to the original grid. Thus one might point out that the ratings on construct E have a far greater spread (1–6) than the ratings on construct A (3–5). Because construct E is viewed in strong terms, it appears nearer the outside of the grid mapping. A glance at the columns of the grid will show that elements 3, 5 and 7 are rated similarly on all constructs, which is why they appear in a cluster in Fig. 9. The lowest ratings on construct F are achieved on these three elements, which is why the low pole of this construct (*worked hard*) is also associated with the group. And so on.

The statistics generated by either of these programs can also be useful in providing "standard scores" for the grid. The most common standard scores are the "distance" measures between particular pairs of elements and constructs. Honey's manual technique for calculating the distance between two constructs (described above) can be done automatically by general computer programs. Distances between elements can also be extracted (these are roughly equivalent to the *real* distances on the map in Fig. 9) particularly where grids are to be repeated over a time interval. Thus an increasing distance between "Self" and "Boss" over the period of a year might indicate a deteriorating relationship here; a decreasing distance between "Self" and "Ideal Self" might indicate that the person was feeling more self-fulfilled.

Although such scores obviously can be useful, there are two main cautions for those who would promote them. Firstly, there is the danger that people will become lured by the availability of figures to construct standard scores which are highly abstract and which may have no behavioural significance at all. They should only be generated where there is a clear rationale for their construction, and above all, they should be simple. Secondly, the creation of standard scores from grid data is very close to the purpose of normal psychological tests. These tests are designed from statistical summaries of data gained from large numbers of people; whereas grids are intended to provide meaningful information about unique individuals. Grids are not the most efficient methods for providing statistical information, and therefore this kind of information should only be extracted where it is intended to supplement other forms of analysis.

3.3. COMPARISONS BETWEEN COMPLETE GRIDS

It is possible to compare complete grids, but this can only be done when the elements and/or the constructs are identical for each grid to be compared; where there are no common elements or constructs it is necessary to resort either to content analyses or to one of the structural scores described above. Grid comparisons serve two functions: they either demonstrate the differences between grids, or they identify the similarities—

with the possibility of combining grids. This is definitely the domain of the computer packages and both Principal Component Analysis and Cluster Analysis have provided answers to the various problems, as summarized below.

Purpose	Program P.C.A.	C.A.
Analysis of a single grid	INGRID	FOCUS
Analysis of the difference between two grids with identical elements and constructs	DELTA	
Analysis of the commonality in two grids (aligned by elements and constructs)	SERIES	CORE
Ditto, for several grids	SERIES	
Extraction of commonality from several grids with same elements but different constructs	PREFAN	SOCIOGRIDS
Ditto, but same constructs and different elements	ADELA	

An example of the kinds of output provided by these comparative programs is given in Fig. 10. This is the PREFAN analysis for the grids from all the G.T.O.s in the development programme described above (see Fig. 9 for an individual's grid). For purposes of analysis, all seven grids were treated as one large grid with eight common elements and 54 constructs. It is therefore only feasible to plot out the elements on the principle components map; the axes have been labelled according to which constructs were closest to them. Although this can provide a convenient summary of data from a group of people, it does tend to gloss over what might be very great differences within the group. For example, the two elements "Progressive Manager" and "Conservative

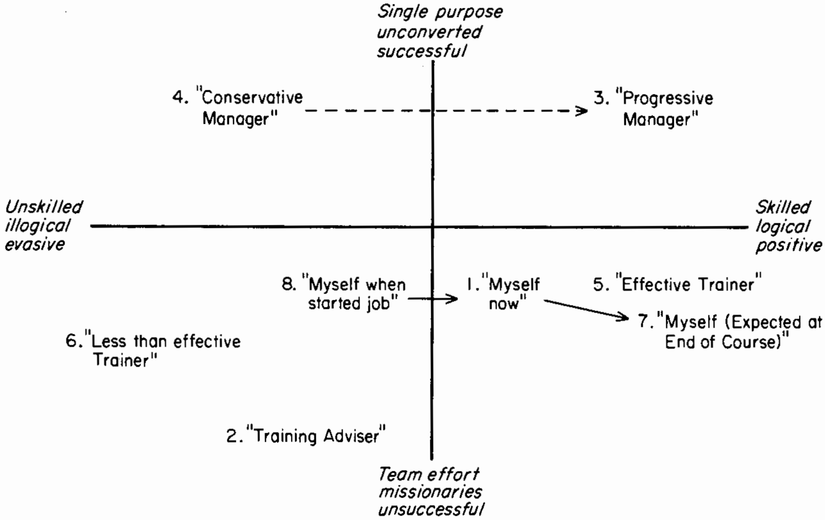

FIG. 10. Mapping of combined grid from all course participants (using PREFAN).

Manager" appear in the above map. By drawing a line between them and examining its direction, it will be seen that a progressive manager differs from a conservative manager in being: *skilled*, *logical* and *positive*. These three constructs are those that come closest, out of the total of 54, to the first component. (It is in cases like this when there are large numbers of constructs to consider that the components can provide useful reference points for summarizing the main patterns.) But there are dangers in trying to combine a number of individual grids into one composite picture. Because when one refers back to the seven individual grids separately, the following descriptions of "Progressive Manager" are obtained:

hardworking, practical
mature, professional
professional, achiever
unpleasant manner
relates well to people, attractive appearance
impulsive
driver, works hard

Thus there is quite a lot of diversity which is collapsed into this one picture. Is it legitimate to group such diverse perceptions into what is supposedly a common view? This should be watched carefully when using comparative forms of analysis. See also Slater (1980) on uses of dual grids in conflict situations.

4. Conclusion

This paper has outlined some of the choices and decision points in the design, analysis and interpretation of grids. Some attempt has been made to indicate where one approach may be preferable to another, but in the long run this kind of judgement can only come with experience—which means a lot of trial and error! All of the different approaches to analysis have their limitations, and their strengths vary according to the task required of them. Computer programs are by no means necessary for the analysis of most grids, but if they are readily accessible they can accelerate and simplify the process. Of the two packages illustrated in this paper, the INGRID package may be preferred for research-oriented applications; whereas the FOCUS package may be preferred for "operational" applications. Some would claim that the latter are far more acceptable uses of the grid since they avoid the danger of alienating the subject, and they are also much more amenable to the increasingly popular interactive packages which enable the subject to maintain full control over the elicitation and interpretation of his grid.

References

BANNISTER, D. & FRANSELLA, F. (1971). *Inquiring Man: The Theory of Personal Constructs.* Harmondsworth: Penguin.

BANNISTER, D. & MAIR, J. M. M. (1968). *The Evaluation of Personal Constructs.* London: Academic Press.

EASTERBY-SMITH, M. P. V. (1980). How to use the repertory grid in H.R.D. *Journal of European Industrial Training, Monograph*, **2**(2). 32pp.

FRANSELLA, F. & BANNISTER, D. (1977). *A Manual for Repertory Grid Technique*. London: Academic Press.

HONEY, P. (1979). The repertory grid in action: how to use it as a pre-post test to validate courses. *Industrial and Commerical Training*, **11**(9), 358–369.

KEEN, T. R. & BELL, R. C. (1980). One thing leads to another: a new approach to elicitation in the repertory grid technique. *Int. J. of Man–Machine Studies*, **13**, 25–38.

KELLY, G. A. (1969). The role of classification in personality theory. In MAHER, B., Ed., *Clinical Psychology and Personality: the Selected Papers of George Kelly*. New York: Wiley.

MURPHY, A. J. (1978). How to win friends and elicit constructs. In FRANSELLA, F., Ed., *Personal Construct Psychology 1977*. London: Academic Press.

NIE, N. W., HULL, C. H., JENKINS, J. G., STEINBRENNER, K. & BENT, D. H. (1975). *Statistical Package for the Social Sciences*. New York: McGraw-Hill.

OSGOOD, C. E., SUCI, G. J. & TANNENBAUM, P. M. (1957). *The Measurement of Meaning*. University of Illinois Press.

RUMP, E. E. (1974). Cluster Analysis compared with Principal Component Analysis. *British Journal of Social and Clinical Psychology*, **13**, 283–292.

SHAW, M. L. G. (1980). The analysis of a Kelly repertory grid. *British Journal of Medical Psychology*, (*in press*).

SHAW, M. L. G. & THOMAS, L. F. (1978). FOCUS on education—an interactive computer system for the development and analysis of repertory grids. *Int. J. of Man–Machine Studies*, **10**, 139–173.

SHEPARD, R. N., ROMNEY, A. K. & NERLOVE, S. B. (1972). *Multi-dimensional Scaling: Theory and Application in the Behavioural Sciences*. London: Seminar Press.

SLATER, P. (1974). Cluster analysis *vs.* principle component analysis: A reply to E. E. Rump. *British Journal of Social and Clinical Psychology*, **13**, 427–430.

SLATER, P., Ed. (1977). *The Measurement of Intrapersonal Space by Grid Technique: Volume 2 Dimensions of Intrapersonal Space*. London: Wiley.

SLATER, P. (1980). Construct systems in conflict. *Int. J. of Man–Machine Studies*, **13**, 49–57.

SMITH, J. M. (1978). Using repertory grids to evaluate training. *Personnel Management*, **10**(2), 36, 37, 43.

Conversational heuristics for eliciting shared understanding†

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A conversational method is necessary for experimenter and subject to collaborate in the exploration of the world of human beings. Individuals cannot be treated as objects, or be instructed how to take part in an experiment, without the recognition of the autonomy of each person and the invitation to participate jointly in co-operative exploration of the nature of man. An individual can be seen as a personal scientist who forms theories about the world and tests these theories against his personal experience of reality, adapting his theories for a more effective anticipation of events and hence a more competent interaction with his environment.

A suite of computer programs (PEGASUS, FOCUS, MINUS, CORE, ARGUS and SOCIOGRIDS) has been developed, each one acting as a cybernetic tool to enhance man's capabilities to understand both himself and his relationships with other perspectives of the world. PEGASUS is described, including PEGASUS-BANK which can be used to explore the relationship of an individual with another individual (or group). The CORE program can be used to chart change in a person over time, and to find the level of understanding and agreement between two people. Shared understanding within small groups can be investigated using the SOCIOGRIDS program which produces a mapping of the intra-group relationships, and the subject content which shows the extent of agreement in the group.

A study involving the exchange of subjective standards in human judgement is briefly described, and an analogy drawn to the understanding of different perspectives in the treatment of a medical or clinical patient.

Conversational models

A physical science paradigm is not necessarily helpful in dealing with people as subject matter. "Experiments" cannot be conducted on the assumption that either the subject or the experimenter remains unchanged as a result of the interaction. When a physical scientist sets up his experimental conditions he does so in such a way as to stabilize his observations which can then be repeated; that is, measured by other scientists looking from the same point and with the same perspective. The social scientist, however, is unable to keep his subject matter constant in quite the same way. There can no longer be an external observer but only participants helping each other. Therefore interaction between entities able to model themselves and others must necessarily take the form of *conversation.* Many people have recognized the need for personal involvement in learning, motivation and creativity, notably Rogers' (1969) learning contract, Kelly's (1962) and Maslow's (1954) ideas of motivation, and Kierkegaard's (1941) process of man "becoming his potentialities".

† This is partly based on a paper presented to the Twenty-Third Annual North American Meeting of the Society for General Systems Research at Houston, Texas, January 1979.

Several models of conversation are useful in this context. Jahoda & Thomas (1965) have developed a "science of learning conversations" in which the learning experience is viewed from different perspectives.

Purpose	Learner	Teacher
Prospective	1	2
Retrospective	3	4

FIG. 1. The science of learning conversations.

Each of the four quadrants represents a different and valid point of view; quadrant 1 represents the learner's anticipation of the event; quadrant 2 represents the teacher's objectives; whereas quadrants 3 and 4 denote a retrospective view of the experience from the perspectives of the learner and the teacher respectively.

Luft's "Johari Window" (1961) is a model of interpersonal awareness which demonstrates the interaction of the two variables known/not known to self and known/not known to others, elaborated by Hanson (1973) in Fig. 2.

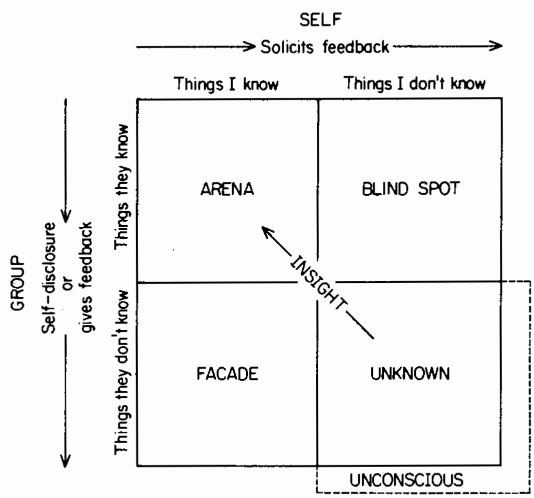


FIG. 2. The Johari Window.

The "arena" is characterized by free and open exchange of information and has an area proportional to the level of trust between the individual and the group. The "blind spot" contains information of which the individual is not aware but may have been communicated to the group by verbal or non-verbal cues. Quadrant 3 is the "facade" which contains information hidden from the group by the individual; and quadrant 4 represents information "unknown" to either the individual or the group.

Pask's (1975) "theory of conversations and individuals" suggests that participants in a conversation cannot be regarded simply as distinct processors, but he distinguishes a "mechanically characterized (M) individual" as a biologically self-replicating system and a "psychologically characterized (P) individual" as a procedure executed in some processor. These P-Individuals are then similar in some ways to roles, perspectives, or points of view existing within and among the former M-Individuals. There may be several P-Individuals in one head as in a conversational private thinking or problem-solving activity, or one P-Individual constituting a conversation in a group. Each of these conversational models contributes to the ways in which a person can become a self-organized learner, able to act effectively in changing himself and his situation to be more viable in the world.

The personal scientist

For many years psychologists and others have been interested in how a person categorizes his experiences and classifies his environment. If the individual can become aware of how he is achieving this organization, he can not only use this awareness to predict more accurately and hence act more effectively, but also to change his system to adapt to specific needs of himself and others. Kelly's (1955) theory of a personal scientist was that each individual is seeking to predict and control events by forming theories, testing hypotheses and weighing experimental evidence. He suggests that the differences between the personal viewpoints of individuals may correspond to the differences between the theoretical viewpoints of scientists.

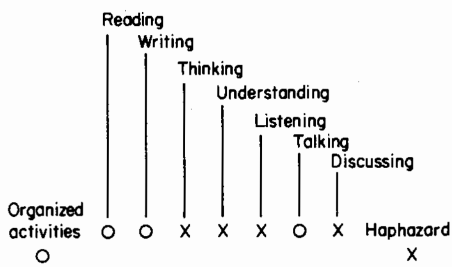
Each personal scientist uses himself as participative subject matter and construes and interprets the results in a personally meaningful way. To do this effectively a conversational method is used which is adapted from the repertory grid (Kelly, 1955). This is used as a tool together with the computer to enable an individual to examine and bring into awareness his own conceptual system. This technique assumes that each person can express his conceptual structure as a unique system of bipolar dimensions known as *personal constructs* through which he experiences life, and categorizes his experiences. This system of constructs acts like a pair of spectacles, focusing and colouring his external and internal worlds, and explains how similar events can produce quite different behaviour in different people.

The repertory grid

The repertory grid is a schema or two-dimensional array of events or observations and abstractions so interlaced as to enable each to have meaning in the context of the other. It is a finite system of cross-references between personal observations an individual has made and the personal constructs he has erected to make sense of his experiences. A set of constructs can be thought of as representing a P-Individual as it is a personal model of a topic emphasizing how a person thinks and feels about the topic in his own terms. These personal observations are known as elements and are chosen from the set of all observations to be relevant to the purpose for exploring this aspect of the individual's own phenomenological world. The elements then might be people, objects, events or ideas such as work colleagues or patients, books or symptoms, events or experiences in a course of treatment, aspects of self or possible careers. Care must be taken to ensure that each of the elements is well known and personally meaningful to the individual; and each construct is important to the individual in the context of the particular problem. Thoughts and feelings, objective and subjective descriptions, attitudes and prejudices all constitute valid constructs. The labels given to the constructs merely serve to remind the participants of the conversation. As an example think of the three learning activities of reading, writing and thinking. In what way are two of these alike and thereby different from the third?

Mr. A says:	"Reading and writing are more alike because they are organized activities whereas thinking is haphazard."
Miss B says:	"Writing and thinking are more alike because they concern only oneself whereas reading involves ideas from someone else."
Mrs. C says:	"Reading and thinking are more alike because they are fun and interesting whereas writing is hard work."

Clearly each person has a different opinion and a different value system. Each of these dimensions is a personal construct because it is expressed in personally meaningful terms, and is significant to the person who used it. As each construct is elicited all the elements are assigned to one pole or the other. In the above example Mr. A's construct became:



To elicit such constructs is a skilled activity. The eliciter must be careful not to contribute parts of his own construct system nor to distort in any way the constructs which are offered by the subject.

PEGASUS

In order to carry out a systematic elicitation process the computer program PEGASUS was developed (Shaw & Thomas, 1978). This program, however, goes beyond the normal clinical method of grid elicitation and also provides an on-going analysis of the links being made between constructs and between elements.

Educationalists, therapists and trainers who use grid techniques will see this program as a useful grid elicitation package which extends the use and application of the grid by using the real-time data processing of the computer to provide feedback during the elicitation, and the analysis of the results immediately on completion. Although this "grid-centred" point of view construes the program as convenient and systematic, it misses the full potential of the "learning-centred" approach of the cognitive model. A personal scientist models reality in order to anticipate events, and the quality of a person's models undoubtedly determines the level of competence and creativity he is able to achieve. There is considerable potential in programs such as PEGASUS to enable a person to become aware of his models, and revise them in order to increase his capacity for anticipation. Awareness raising cannot be measured by the level of achievement of behavioural objectives, but rather it is a change in the personal construing of the individual and the revision of his cognitive model. This "learning centred" approach has recommended PEGASUS to teachers and trainers, industrial inspectors and maintenance engineers, managers and appraisers, in addition to researchers and psychotherapists.

Another version of the program is PEGASUS-BANK. This allows a grid to be stored in the computer representing an area of public knowledge. The user elicits a grid in the usual PEGASUS way, but the feedback is given not only in terms of how the user's constructs map onto each other, but how they map onto the "expert" view. This can also be used to initiate a user into the views and culture of a group, and help him to understand the words and terms used by the experts. This technique, therefore, offers a useful starting point for assessment and training. Although the analysis and the feedback of the results is central to the elicitation, the process of the PEGASUS procedure is both stimulating and demanding. The computer acts as a cognitive mirror in which the user sees himself, and with PEGASUS-BANK the world external to himself.

Shared understanding

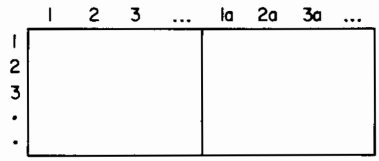
The PEGASUS-BANK technique of storing in the computer a bank of constructs which represents an area of public knowledge or the construing of a group of specialists, shows how an individual can use the grid methodology to interface between his early gropings and the articulate formulations of the group. It can also be used for two people to come to an understanding of each other. One may elicit a grid which is stored in the computer for the other to use as he elicits his own grid using the same elements. At each stage the bank may be increased or modified hence encouraging each of the two participants to take on the construct system of the other by mapping out the similarities between the patterning, and hence meanings can be exchanged between the pair. Alternatively, if each elicits a grid independently, using a shared set of elements, the two grids may be compared by matching the patterning of the responses.

Whether or not the grids have been elicited on separate occasions, if the element and construct labels are the same in both grids they 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 (see Shaw & Thomas (1978)).

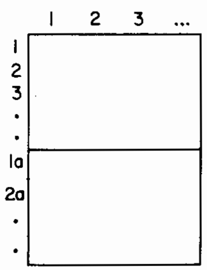
An important property of a construct is its treatment of the elements of construction. If two constructs have been used in relation to the same element set, then the way they act on the elements may be compared. If the same person elicits two grids with the same element and construct names on two separate occasions, which are then processed on MINUS, it is possible to see the elements and constructs which have remained the same in meaning, and those which have changed in some respect. One may assume that those constructs less liable to fluctuation over short periods of time in which no excessive physical or emotional upheaval has taken place are likely to be core constructs; that is, those which govern a person's maintenance processes, as opposed to those which can be changed without seriously affecting the core structure. If the same constructs persist over a series of grids this becomes even more likely.

The CORE program

A more flexible approach to identifying core constructs is developed in the CORE program. In order to measure change in the two dimensions of elements and constructs, each is held constant alternately whilst change in the other is calculated. The two grids have the same element and construct names, therefore one assumes, say, the constructs are the same and examines the clustering of the elements when the two grids are analysed as one using part of the FOCUS algorithm:



If in fact element 1 and element 1a (that is element 1 in the second grid) are being construed in the same way they will be highly matched in the double grid. If then the two grids are processed by keeping the elements constant and allowing the constructs to vary, similarly, the constructs operating on the elements in the same way on both occasions will cluster together:



By alternating in this way no assumption is made about the stability of any element or construct.

If the user is more interested in constructs and does not wish to delete elements, or vice versa, the program allows just constructs to be deleted until the decision is made to stop. Flexibility is thereby given to the person who most understands the content of the grid to use his subjective judgement, rather than taking a statistically significant but nevertheless arbitrary cut-off point. If the user continues until all match values are 100%, then the two partial grids which remain will be identical and as such may be designated "the core grid".

Exchange grids

Agreement and understanding can each be negotiated in a similar way using the CORE procedure. To do this two people each elicit a grid in an area of common knowledge or experience. Each may choose his own elements independently of the other and elicit and rate his constructs quite separately. Each then makes two copies of his grid leaving out the rating values. Each of these copies is filled in by the other person, one as he himself uses those constructs on those elements and the other as he thinks the original was completed. There are now six grids:

(1) A's grid;
(2) B's grid;
(3) A's grid filled in by B as B wants it filled;
(4) B's grid filled in by A as A wants it filled;
(5) A's grid filled in by B as B thinks A did it;
(6) B's grid filled in by A as A thinks B did it.

These have been called "exchange grids" (Mendoza, 1970). If these are then processed in pairs on CORE: 1 and 3, 2 and 4 represent agreement; 1 and 5, 2 and 6 represent understanding. The extent of the agreement and of the understanding will be indicated by the relative size of the core grid obtained, and the areas of disagreement and misunderstanding will be mapped out by those constructs and elements which are discarded at different levels of match during the process. This then opens up an area for conversation, and negotiation can take place securely grounded in the grid structure.

SOCIOGRIDS

Although CORE offers new potential for investigating understanding between two people, it is not always appropriate to use the same element and construct names. Kelly's position was that both elements and constructs should be elicited from the individual, but when neither elements nor constructs are common, measures of overlap are difficult to derive.

Elements are more easily shared than constructs, since they are representatives of the universe of discourse. If they are physical entities or shared experience, both participants are likely to be able to construe them without difficulty. Personal constructs are then elicited individually, resulting in two grids with the same elements but each with different constructs. These two grids can then be compared, the FOCUS algorithm providing a convenient method for this comparison. As the two grids have the same elements but different constructs they may be combined and treated as one grid, the first n constructs being from person A and constructs $n+1, \ldots, N$ from person B. By matching each of the rating patterns of the constructs from grid A in turn with each of the constructs in grid B, a measure of the extent of similarity between the two grids can be established.

Kelly's commonality corollary states that: "to the extent that one person employs a construction of experience which is similar to that employed by another, his processes are psychologically similar to those of the other person." This does not imply that this similarity is necessarily the totality of his psychological processing. Imagine an extreme case. In construing a certain topic, person A habitually uses four constructs while person

B habitually uses two. The constructs used by B are identical to two of A's constructs. Now, when in conversation about this topic, A may be able to empathize totally with B, as B is using exactly the same construing as A, but B may not be able to empathize with A when A is using those constructs not common to B. The measure of commonality used is sensitive to this situation; the mapping of grid A onto grid B produces a different degree of similarity from that of grid B onto grid A. Clearly if A and B are using constructs in the same way to order the elements then this will be revealed despite the verbal labels which have been attached to them. This technique can then be extended to investigate the commonality in a group by considering the overlap between every possible pair of grids. This is the basis of the SOCIOGRIDS program.

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 "mode" grid of the most commonly used constructs by all the members of the group is extracted and focused, exhibiting the content of the shared construing in the group. Each construct in the mode grid has been obtained from one individual in the group and is in no way changed when used in the mode. This grid then is not a consensus grid which averages out the individualities to produce a pale imitation of the group, but is strongly weighted towards the commonality or intersection of construing within the group. Due to this format the constructs tend to be highly clustered in the mode grid, and generally these clusters display a high degree of both literal and conceptual similarity in the construct labels as denoted by Duck (1973). In a field where more technical language is used it would be impossible for the non-expert to rely on his own judgement of what constituted literal and conceptual similarity. This seems a powerful technique for identifying such similarity by a more reliable process than has been used in the past (see Thomas, McKnight & Shaw, 1976). The mode grid can then be used as a common referent for the group with which each individual may be compared.

A sequence of sociometric diagrams designated "socionets" is produced from the matrix of similarity measures between pairs of individual grids. The highest related pair is picked out initially as a subgroup where commonality of construing occurs, followed by the subgroups defined by the rank ordering of all the similarity measures. This set of socionets shows those members of the group who have the most in common and those with strongly individualistic viewpoints. For example, in the treatment of a patient, the patient's problem may have quite different meanings for a harrassed nurse, a chief consultant, or a physiotherapist. The position, responsibilities and experience of each of these people will have led them to develop a different set of personal constructs and so each will construe the patient differently. The constructs which a person brings to a situation lead him to see that situation in a particular way. They lead him to select certain aspects and ignore others and they determine the way in which perceived dimensions are combined into an overall meaning. For example, the details which concern the nurse are unimportant to the consultant, and the physiotherapist might see that a particular treatment would be suitable for Mr A but not for Mrs B.

The grid techniques offer a means of discovering the terms in which these different people, all of whom have the same objective with respect to the patient, appreciate the problems involved. It can reveal the basic structure of values which forms the basis of human judgement, often only vaguely appreciated by the individual himself.

Exchange of subjective standards

A study was carried out recently into subjective standards in the inspection of knitwear (Pope, Shaw & Thomas, 1977; Shaw, 1980*b*). At first sight this is totally removed from medical and clinical practice, but on examination it can be seen to be an analogous situation. The purposes of the study were to help each manager, supervisor and inspector to become more aware of his or her own personal dimensions for judging faults in garments and to explore the pattern of judgements within the group in order to discuss the similarities and differences that exist between individuals. Four final inspectors from the production line out of a total of eight participated in the exercise together with the inspection supervisor, the production manageress, the production manager, the divisional manager and a trainee production technologist. Figure 3 shows the hierarchy within the organization of those involved.

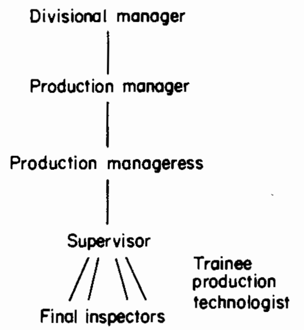


FIG. 3. The organizational structure.

Each member of this group was shown a range of garments currently in production and asked to describe the process of inspection and the faults which would specifically be looked for during the inspection procedure. As this was done, the faults mentioned were noted and subsequently used as elements in a grid. After each person had separately identified elements of quality and elicited a grid, the group, excluding the production manager and divisional manager, met together to examine the total list of elements produced, and negotiate a common set of elements which could be shared by them all. (The reason for the exclusion was partially practical in terms of time commitment, and partially to avoid inhibiting the less senior members of the organization.) Each person then elicited a new grid using the negotiated element set, and the constructs which had been personally produced on the previous occasion with the addition of one offered construct. The opportunity was given to add extra elements and constructs. The two grids from each person were then FOCUSed, and the second set analysed on SOCIOGRIDS. A number of other analyses were performed, including a clustering of the original element list from the verbal labels, and the extraction of a grid made up of the offered construct from each person.

A week after the initial grids were elicited, each person was presented with his/her personal results, and the group results. During the feedback of the results, each person was encouraged to identify his/her position with respect to the other people in the group, both from the links made in the socionets and from the list of constructs ordered by common usage; also examining similarities and differences shown by the clustering of elements and constructs in the personal individual grids.

Following the individual feedback sessions, the four inspectors met to discuss the variety in the group. This led to the negotiation and exchange of meaning of the exact nature of the faults concerned.

Figure 4 shows a grid from the first set elicited from one of the final inspectors using her own elements. The elements used by people in other positions in the company varied somewhat, but all agreed on a common set of elements for the second set of grids.

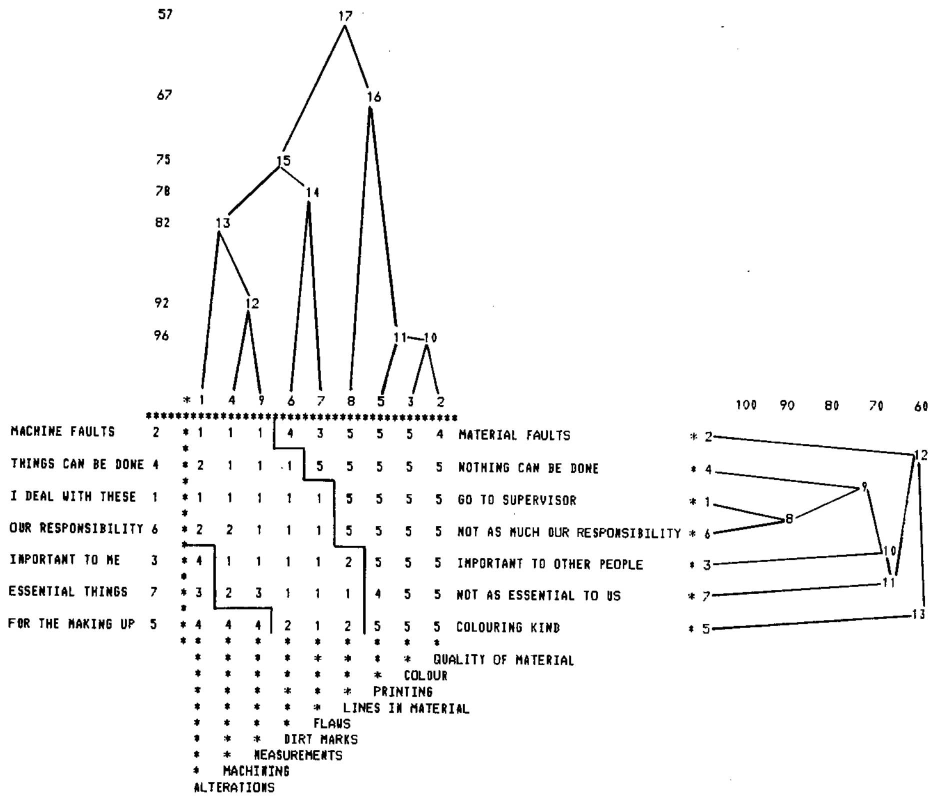


FIG. 4. A grid on faults in garments from the first set using a 5 point scale.

Figure 5 shows the mode grid made up of the eleven most shared constructs. Two of the inspectors and the divisional manager contributed nothing to this grid, whereas one of the inspectors contributed four constructs, and the production manager contributed three. The element clusters show the three faults "shading fault", "fabric fault" and "print fault" to be construed similarly on the left of the tree, and the three faults

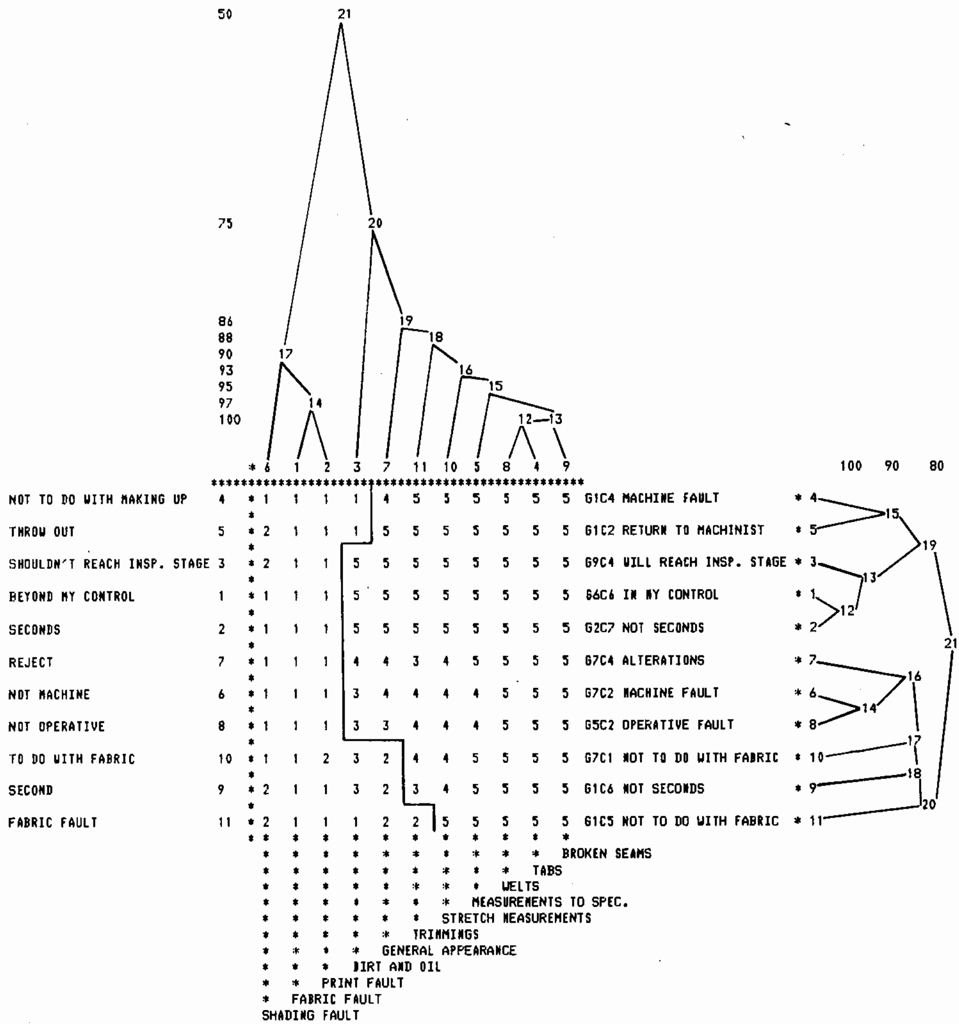


FIG. 5. The mode grid on faults in garments.

"broken seams", "tabs" and "welts" to be construed similarly on the right of the tree. This right-hand cluster then gradually incorporates each of the remaining faults one at a time, until "dirt and oil" enables it to join with the other cluster. It can be seen that "dirt and oil", "general appearance" and to some extent "trimmings" are viewed variably, not being clearly to one or other pole of all the constructs as the other faults are.

Since everyone was using the same set of elements, it was possible to extract the one offered construct "very important—not so important" from each grid. This is shown in Fig. 6. The construct tree now shows the relationship of the people who took part in this study with respect to the importance they attach to different faults in the garments. It is interesting to note that reading down from the top of the construct tree one is reading down the hierarchy within the group; 8 is the divisional manager, 7 is the production manager, 6 is the manageress, 5 is the supervisor, 1 to 4 are the inspectors and 9 is the

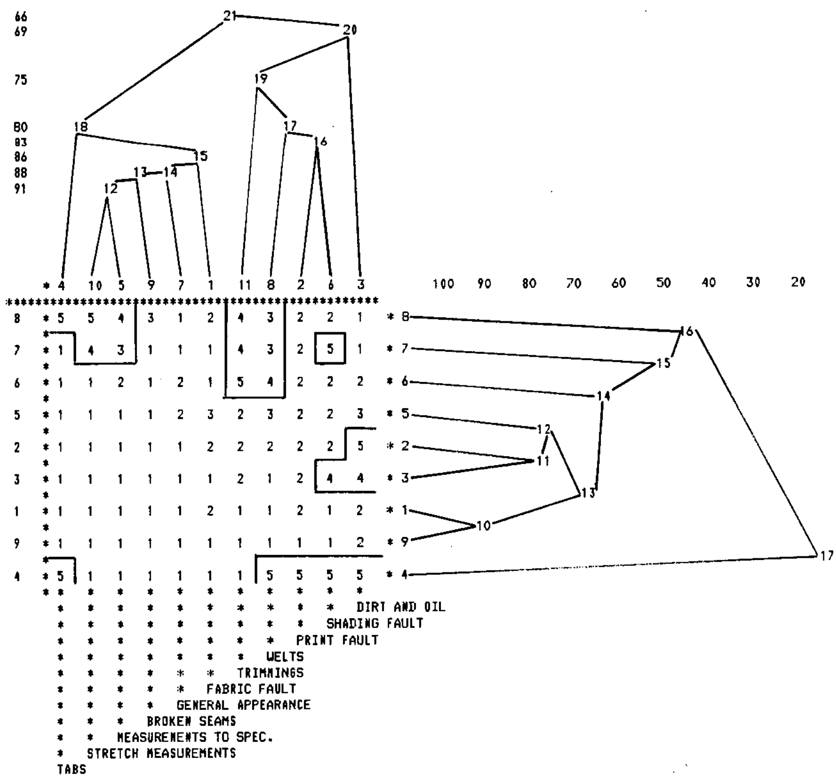


FIG. 6. The "offered construct" grid on faults in garments.

trainee. A possible explanation of the separateness of 4 is the difference in the use of the 1 to 5 scale. Whereas person 4 used the two poles 1 and 5, most other inspectors used 1 and 2 to differentiate importance.

Figure 7 shows diagrammatically the system of connections between the participants (expressed as links to the three grids which were most like the person's own grid). Points of interest are:

(i) three inspectors and the trainee production technologist shared similar views of faults;
(ii) one of the inspectors seemed to differ from this group;
(iii) the supervisory and management group shared similar views of faults although the similarity is less strong and differs from that of the inspectors;
(iv) the patterns of reciprocal similarities, i.e. among inspector and trainee, between supervisor and production manager and divisional manager;
(v) each of the supervisory/management group relate to inspector 2.

The results show that different roles within the company incorporate different viewpoints of quality, and provide a foundation for the negotiation and exchange of meaning. This can help both the company and the individuals to realize each position and how it contributes to the whole. In the case of the patient also, a better understand-

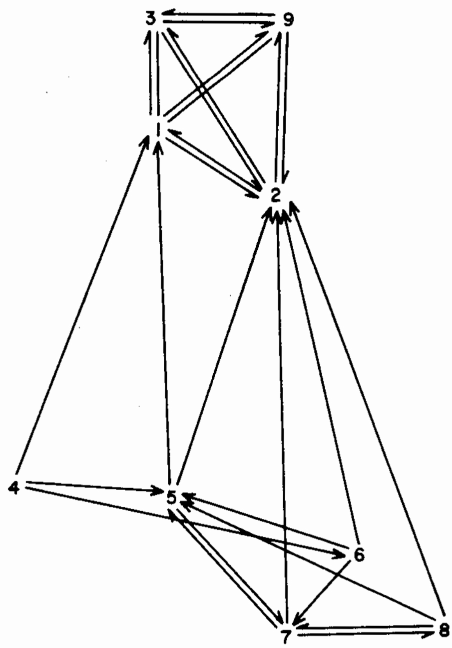


FIG. 7. Diagram showing the systems of connection between participants.

ing of each person's point of view, how he or she sees the links in the whole system, and awareness of effect of individual action within the system must contribute to a more viable working relationship, and hence benefit all concerned.

Conclusion

The grid is therefore a rigorous but flexible structure which is held by the computer whilst the system of constructs is elicited from the individual and processed in a participative way (Shaw, 1980*a*). The personal scientist can use the grid together with the computer as a sensitive instrument to enhance his essentially human skill, not as a machine which removes the human part of the work and reduces man to a moronic button-pusher. Gaines (1977) goes even further by suggesting that the computer can become more like a colleague, expressing sympathy and understanding to the user.

With the decreasing cost of microprocessors, the personal computer will soon be commonly available to anyone. These grid techniques may then be incorporated as additional resources in the cybernetic toolbag to explore systems of personal meaning in a non-directive and supportive way, enabling the individual to build, review and revise his personal models of the world and hence predict and act more effectively.

References

DUCK, S. W. (1973). *Personal Relationships and Personal Constructs—A Study of Friendship Formation.* New York: John Wiley.

GAINES, B. R. (1977). Minicomputers in business applications in the next decade. Paper for Infotech State-of-Art Report on *Minis Versus Mainframes.*

HANSON, P. C. (1973). The Johari Window: a model for soliciting and giving feedback. *The 1973 Annual Handbook for Group Facilitators*, pp. 114–119.

JAHODA, M. & THOMAS, L. F. (1965). A search for optimal conditions of learning intellectually complex subject matter. *3rd Progress Report.* Centre for the Study of Human Learning, Brunel University.

KELLY, G. A. (1955). *The Psychology of Personal Constructs.* New York: W. W. Norton.

KELLY, G. A. (1962). Europe's matrix of decision. In JONES, M. R., Ed., *Nebraska Symposium on Motivation.* University of Nebraska Press.

KIERKEGAARD, S. (1941). *Concluding Unscientific Postscript.* Princeton University Press.

LUFT, J. (1961). The Johari Window. *Hum. Rel. Train. News*, **5**, 6–7.

MASLOW, A. H. (1954). *Motivation and Personality.* New York: Harper and Row.

MENDOZA, S. (1970). Personal construction of the world and its control and development by the individual. Unpublished B. Tech. Project. Brunel University.

PASK, G. (1975). *The Cybernetics of Human Learning and Performance.* London: Hutchinson Educational.

POPE, M. L., SHAW, M. L. G. & THOMAS, L. F. (1977). A report on the use of repertory grid techniques in final inspection. Centre for the Study of Human Learning, Brunel University.

ROGERS, C. R. (1969). *Freedom to Learn.* Columbus, Ohio: Charles Merrill.

SHAW, M. L. G. (1980*a*). Two roles for the computer in cognizant systems. In *Progress in Cybernetics and Systems Research Vol. V* (TRAPPL, R., Ed.), Halsted Press, 377–381.

SHAW, M. L. G. (1980*b*). *On Becoming a Personal Scientist: Interactive Computer Elicitation of Personal Models of the World.* London: Academic Press.

SHAW, M. L. G. & THOMAS, L. F. (1978). FOCUS on education—an interactive computer system for the development and analysis of repertory grids. *International Journal of Man–Machine Studies*, **10**, 139–173.

THOMAS, L. F., MCKNIGHT, C. & SHAW, M. L. G. (1976). Grids and group structure. Paper presented to the Social Psychology Section of the B.P.S., University of Surrey.

Reflective analysis

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The paper describes a method of computer assisted reflective learning capable of being used by managers. The method enables managers to explore the value of their past experience in relation to a particular problem context; to consider how their own experience relates to that of other managers; and finally to create design criteria for strategic options within a problem context capable of commanding a consensus between the managers. The paper concludes that the method represents a new departure in the use of computers for supporting strategic management.

Introduction

The methods described in this paper were developed within a project funded by the London Graduate School of Business Studies and the National Development Programme in Computer Assisted Learning: the Management Decision-making Project. The methods are an example of how software developed by that Project can be used. The software and its application are now supported by the Management Learning Project based at the London Business School and funded by the Manpower Services Commission. The aim of this paper is to describe how the author uses that software for supporting reflective learning, rather than to describe the characteristics of the software itself.

The Management Decision-making Project (Hooper, 1977; Fielden & Pearson, 1978) was set up to produce learning techniques capable of developing the intuitive, qualitative and judgemental aspects of decision-making. It was based on the assumption that there is something beyond rational, analytic and objective decision-making which the practising manager could recognise even if the academic could not. Loosely referred to as judgement, such processes become most apparent when non-routine decisions have to be made and the manager is involved in breaking new ground; or when the decisions to be made are themselves hard to define because of the ambiguous nature of the circumstances in which the need for a decision has arisen.

The hypothesis was that the rational analytic mode of decision-making could be explained wholly by reference to phenomena external to the decision-maker: as a mode of decision-making it was therefore wholly *object-referenced.* Judgement on the other hand involved the decision-maker in reference to the quality of his own past experience: it used knowledge that was *subject-referenced* (Boxer, 1978). Subject-referenced knowledge was therefore vitally different from object-referenced knowledge because its expression had to be subject centred, and it had to be observed relative to the subject's point of view. This paper describes a method of enabling managers to explore their subject-referenced knowledge in relation to a particular problem context. Boxer (1980) describes the theoretical basis underlying the design of this method.

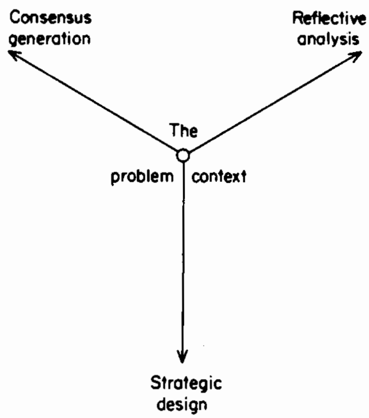

FIG. 1. Three ways of exploring subject-referenced knowledge in relation to a particular problem context.

The assumptions underlying the use of the method described in this paper are firstly that a group of managers using it will be faced with a problem which exists within the context of their organisation as a whole; and secondly, that the managers will be interdependent in their capacity to act on the problem. Figure 1 identifies three facets of the method: firstly Reflective Analysis, concerned with enabling the manager to recognise his own subject-referenced knowledge in relation to the problem context; secondly Consensus Generation, providing a way of enabling each manager to explore the relatedness between his own and each other manager's subject-referenced knowledge; and thirdly Strategic Design, building on the shared language negotiated between the managers by examining value trade-offs between the managers as a result of selecting different strategic options.

The method described in this documentation is not intended as an alternative to, or in any way a replacement for the various analytical methods already familiar to managers. Rather the method's focus on subject-referenced knowledge should be seen as providing an essential complement to the typically object-referenced nature of other methods. Throughout the paper there is an example of the use of the method, shown as computer printout. The characters typed by the user have been underlined, and the examples given are personal, being an individual's reflections. The content of the examples concerns the purchase of a motor-car: this example has been chosen because it is a practical problem which many readers will have had to face. It is also a problem which clearly involves qualitative subject-referenced values as well as a need for some hard-headed analysis.

Supporting reflective learning

Underlying the distinction between subject-referenced and object-referenced knowledge is an interpretation of George Kelly's Theory of Personal Constructs (Kelly, 1955). The operationalisation of that distinction in the method being described here has been based on the principles of Repertory Grid Analysis (Fransella & Bannister, 1977). The explanation of the theoretical basis on which the method is constructed is given more fully elsewhere (Boxer, 1980), and what follows summarises aspects of that paper.

PERSONAL CONSTRUCTS

Kelly's conception of mind was that it served a useful function for the individual by anticipating experience, whether that experience was internal or external. Kelly's theory (itself a construction) was that mind "construed" experience, and the name he gave to the construing process was the "construct". He then went on to say that 'constructs' could be thought of in two ways: either as *pre-empting* experience from being construed in alternative ways; or as not pre-empting but rather *relating* experience to other experience. The former mode of construing he described in terms of "pre-emptive" and "constellatory" constructs, depending on the degree to which the construct excluded other ways of construing; and the latter he described in terms of "propositional constructs. The method described in this paper represents the pre-emptive or constellatory construing as experiences, options or elements: *what* is experienced; and it represents propositional construing as concepts of value or adjective pairs: the *how* of experiencing.

The distinction made by Kelly is the one made earlier between object-referenced and subject-referenced knowledge. In terms of a problem and its context, a description of the content of a problem is pre-emptive. It serves its purpose of controlling by excluding and making particular and definite what would otherwise be general and amorphous. The description of the problem in relation to its context on the other hand is propositional. While being based on an assumption about content, it serves the purpose of relating. A propositional description identifies dimensions of relatedness between the current content of the problem and managers' past or imagined alternative definitions of the problem. The analysis of subject-referenced knowledge thus provides the manager with a means of integrating his experience and dealing with problems in relation to their context.

Pre-emptive and constellatory constructs form a class of concepts therefore which are object-referenced: they can be communicated by exclusive reference to the objective content of experience. Propositional constructs, however, form a special class of concepts which are subject-referenced: they can only be communicated by reference to the individual's experience of the problem content/context boundary—his point of view. The name given to the expression of this form of construing is *core structure*. Reflective Analysis has been developed as a method of enabling the individual to reflect on the nature of his core structure. The method acts as a device for enabling the individual to reflect on similarities implicit in his concepts of relatedness: a process which enables him to develop his awareness of his own core structure as a whole.

These similarities identify underlying patterns in "how" the individual has experienced: the quality of his experience.

USING REFLECTIVE ANALYSIS

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EXE-*NIPPER
NIPPER

NIPPER SYSTEM COPYRIGHT 1977 C.E.T.
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Further information from: MANAGEMENT LEARNING PROJECT,
                          LONDON BUSINESS SCHOOL
                          SUSSEX PLACE, REGENTS PARK
                          LONDON  NW1 4SA
                          (Phone 01-724 1517)

* OBEY REFLEX


          REFLECTIVE ANALYSIS
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EXPLANATION?
?YES
These programs have been written to support Reflective
Learning and the generation of consensus between managers:

     1. Identifying concepts of value based on a manager's
        past experience and relevant to the evaluation of
        current options - PAST REFLECTION.
     2. Evaluating current options in terms of concepts
        of value - OPTION ANALYSIS.
     3. Evaluating current options in terms of another
        manager's concepts of value when there are no
        shared options - CONCEPT ANALOGIES.

     4. Identifying how other managers' values differ in
        relation to a shared problem- ROLE NETWORK ANALYSIS.
     5. Identifying how another manager's concepts of value
        relate to your own - EXCHANGING VIEWS.
     6. Identifying groups of options which can form a basis
        for collective action between managers with a
        shared problem - CONSENSUS GROUPING.
```

Within the software supported by the Management Learning Project ("NIPPER") there exist six programs written by the author and referred to collectively as Reflective Analysis. The programs are concerned with helping the manager know his point of view both in relation to his past experience (Reflective Analysis) and also in relation to the views of others (Consensus Generation). The programs also help a manager or group of managers to create design criteria in terms of their values (Strategic Design). The techniques of analysing and designing organisation structures in terms of the design criteria of managers within an organisation are dealt with elsewhere, being beyond the scope of this paper (Boxer, 1979). Within the three facets of the method, Past Reflection allows the manager to explore core structure in relation to his own past experience. He selects the past experience on the basis of its relevance to the current problem. Option Analysis enables him to consider how that core structure impacts on a present set of options within the problem context. Concept Analogies then allows the manager to draw on other managers' experience when there is no common set of options or past experiences. Role Network Analysis looks at what variety of value perspectives exist relative to the problem amongst a group of managers. Exchanging Views allows those managers to see in detail how their views differ relative to the problem; and finally Consensus Grouping allows the group of managers to perform an option analysis collectively. Figure 2 summarises these different programs in terms of the three facets of the method shown in Fig. 1.

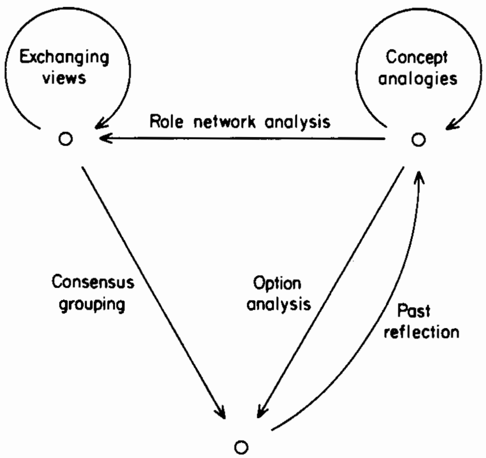


FIG. 2. The different programs within reflective analysis.

The difficulty with using the method is the fact that a manager will act on and react to external events in ways which through examination by himself and others will reveal a "theory-in-use": there will be patterns or regularities in his behaviour which he may or may not be conscious of. Equally the manager will talk about himself and external events and seek to explain his actions and the actions of others: he will have an "espoused theory" of action (Argyris & Schon, 1974). The manager's actions and therefore his theory-in-use will be influenced by his personal feelings, preferences, ambitions and particular experiences as well as by the constraints of the problem and its context. If the manager wishes it to be so, there need be little connection between what he says and what he does. No amount of reflection will change this, and thus use of the method will have little impact on the problem.

The value of the method, however, follows from the fact that much of the split between managers' espoused theories and theories-in-use comes from the manager's inability to incorporate context and value in his espoused theories. The method of supporting reflective learning provides him with a way of learning to do this, by providing the manager with a medium sensitive to the expression of concepts of value and relatedness—his core structure. Thus the benefit which follows from using the method is the possibility of improving the manager's ability to deal with himself and the organisation as a whole; of improving the quality of lateral communication between managers; and of developing the organisation's capacity to function as a whole. The use of the method is therefore most appropriate for managers likely to have the greatest difficulty in keeping espoused theories and theories-in-use congruent: managers in complex organisations who are concerned with managing structural change, and who work with a high degree of functional specialisation and interdependency in their organisation's activities.

CONCEPTS OF VALUE

Past Reflection provides a method whereby the concepts of value implicit in an individual's preferences can be distilled out of his experience of past problems which he can remember as being relevant.

```
CHOOSE ONE OF THE FOLLOWING:

FORMS FOR REMOTE USE?
?NO
PAST REFLECTION?
?YES
HP2640 TERMINAL?
?NO
```

Past Reflection enables the user to consider a number of different sets of past experiences which might be relevant to the current problem. In each case the user identifies the content of the past experience (the element experiences) and different concepts of value which he feels are significant.

```
              PAST REFLECTION
              ***************

PLEASE ENTER IDENTITY CODE ? 4
FILE NUMBER?
?1
DATA ON FILE?
?NO
HOW MANY ELEMENT EXPERIENCES?
?5
ENTER 5     20 CHARACTER LABELS FOR THEM
< TR4A
< ROVER TC
< FIAT 131
< CITROEN GS
< RENAULT 12
HOW MANY EVALUATIVE CONCEPTS?
?13
ENTER 13    20 CHARACTER LABELS FOR THEM
< COMFORTABLE
< COSTLY TO RUN
< ROOMY
< DIFFERENT
< WELL FINISHED
< EASY TO MAINTAIN
< GOOD VALUE
< ROBUST
< FLEXIBLE
< TINNY
< WELL DESIGNED
< POWERFUL
< AIRY
```

Through a process of reflecting on how he feels about those past experiences, the user can identify patterns along a continuum which reflect how he feels about each experience in relation to the other experiences.

```
WHEN RATING THE ELEMENTS AGAINST EACH CONCEPT
USE LETTERS TO REPRESENT THE ELEMENTS AS FOLLOWS:-
          a - TR4A                          b - ROVER TC
          c - FIAT 131                      d - CITROEN GS
          e - RENAULT 12


                        LOW                                                HIGH
COMFORTABLE             !__________________________________________________!
[redacted]              ?             A EC            D          B

COMFORTABLE             !_____________________a_ec__________d__________b_____!
OK ? YES
```

This pattern defined by the user is the "meaning" for him of the particular concept of value in terms of those particular experiences. The process of becoming conscious of and expressing these patterns is fundamental to the process of reflection. The user can take a very long time and derive a great deal of insight purely through defining these patterns.

```
COSTLY TO RUN           !-----------------------b--e---c---d-----------a---!

ROOMY                   !----------a-------------------c-------db-----e---!

DIFFERENT               !-------e-c------------d------b--------------a---!

WELL FINISHED           !--------c-----------a--------e--------d--------b--!

EASY TO MAINTAIN        !----d------------b---c--a--------------e----------!

GOOD VALUE              !-------a---------c----d---------b-------e----------!

ROBUST                  !---------d----c----a------b----------e------------!

FLEXIBLE                !--------------a---------c--d----b-------e-----------!

TINNY                   !---b---a---d------e-------------------------c------!

WELL DESIGNED           !---------c---------e----a-------d--------------b----!

POWERFUL                !----------d------e--------c--------------b----------a!

AIRY                    !---------d------c------e--------------b----------a---!
```

Assuming that the experiences chosen by the user are different in his mind, then the first thing that can be done is to check whether the differences which he has expressed correspond to his feelings about their differences. Concepts of difference are synthesised by the program in the computer, so that "TR4A" is difference of experiences to experience of TR4A.

```
EXPERIENCE DIFFERENCE?
?YES

EXPERIENCE DIFFERENCES:

          a - TR4A                          b - ROVER TC
          c - FIAT 131                      d - CITROEN GS
          e - RENAULT 12

                        LOW                                                HIGH

TR4A                    !a-----------------------bc-d-e---------------------!

ROVER TC                !b---------------d--e--a--c-------------------------!

FIAT 131                !c-----------------de---a--b------------------------!

CITROEN GS              !d---------------bce-------a-------------------------!

RENAULT 12              !e-----------------cdb--------a-----------------------!
```

Thus the user can check that experiences which he feels ought to be very similar or different have in fact been expressed as such in terms of the concepts he has defined. If not, he can of course introduce new concepts to more clearly express his feelings. The program measures similarity or difference by calculating the Mean Absolute Distance between element positions for all the concept continua used. This is easy to calculate by inspection of the original patterns, and thus makes it easy for the user to confirm his view of what the program is doing. (The program does this by mapping the continuum onto an arbitrary number interval chosen by the programmer for convenience and sensitivity to element position. In the example this interval is 0–99.) The measure is explained in detail in the next section.

Considering the adequacy of the concepts used to express the differences existing between the experiences is one way of expanding the capacity of the concepts identified to reflect those differences. The purpose of reflecting on past experience is, however, to locate the sources of the user's present preferences. Examining concept similarity provides the means whereby he can relate the individual concepts to his present sense of preference. The method provides three alternative analyses of similarity for doing this.

```
CONCEPT SIMILARITY?
?YES


SIMILARITY GROUPING OF CONCEPTS:


 ( 8) GOOD VALUE           AND FLEXIBLE          => A[ SOUNDNESS  ]
```

The two concepts which were most similar in the example were "good value" and "flexible". For the user, the concept of value which ran through both these concepts was the "soundness" of the car—the extent to which it was tried and tested in use. (The number at the left-hand side indicates that the user rated the experiences on average 8% differently along the continuum for these two concepts.) The next three most similar concept pairs were as follows:

```
(10) WELL FINISHED      AND WELL DESIGNED      => B[ ENGINEERED  ]
(10) POWERFUL           AND AIRY               => C[ SPORTY      ]
(12) EASY TO MAINTAIN   AND ROBUST             => D[ BASIC       ]
```

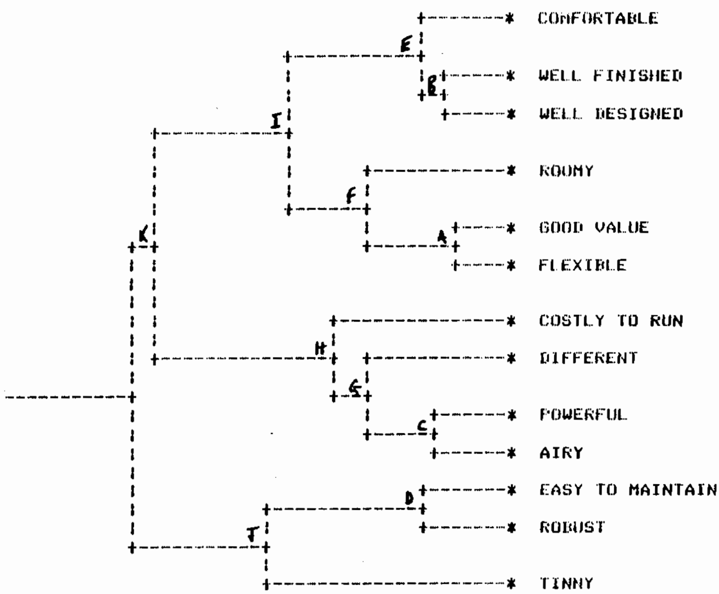
Again the user reflected on the underlying concepts, and thought of a concept label to identify their relatedness. The program assumed that the user could think of some appropriate label for each underlying concept and produced a label for it A[ ], B[ ], etc. It then replaced the pair of concepts by the new one. The next most similar grouping was:

```
(12) COMFORTABLE        AND B[ENGINEERED  ]    => E[ QUALITY     ]
```

"Comfortable" was closer to the pair of concepts "well finished" and "well designed" than to any other concept or group of concepts. The new concept underlying this similarity was for the user "Quality". The computer continued to hypothesise about similarities and the user continued to use them as a basis for reflection.

```
(19) ROOMY                  AND A[ SOUNDNESS    ]     => F[ FAMILY      ]
(20) DIFFERENT              AND C[ SPORTY       ]     => G[ FLASH       ]
(24) COSTLY TO RUN          AND G[ FLASH        ]     => H[ EXTRAVAGANT ]
(30) E[ QUALITY    ]        AND F[ FAMILY       ]     => I[ BOURGEOIS   ]
(34) D[ BASIC      ]        AND TINNY                 => J[ UTILITARIAN ]
(49) I[ BOURGEOIS  ]        AND H[ EXTRAVAGANT  ]     => K[ ———         ]
```

The program also produced a "family tree" representation of the similarities between the concepts. The particular shape of this tree reflects the strengths of similarity between concepts, and thus has its own "gestalt". With experience of the method, the user learns to use the "family tree" as well as the verbal analysis.



EXPRESSING CORE STRUCTURE

There are three different ways of examining similarity between concepts and each produces a slightly different insight into core structure. These different insights are used to enable the user to work towards four objectives in expressing core structure:

(1) to identify *anchor groups* of concepts which correspond to significant dimensions of construing;
(2) to *ground* those groups on the content of experience with concepts which arise directly out of that experience;
(3) to *spread* the concept structure over as wide an area of construing as possible;
(4) to be able to make *normative* statements relating the concepts to the individual's overall evaluative point of view.

Each concept label identifies an adjective pair, one of which may simply be the negative of the other, but which together break up the continuum into two parts. The break-point between these two parts corresponds to indifference between the two adjectives. Proceeding in either direction then corresponds to increasing degrees of the concept identified in terms of one or other of the adjective pair.

For example the user's concept "Tinny" refers to a continuum:

```
Tinny:      low                          high
            -------A----B--------C--------
```

"Tinny" is the name for the continuum as a whole. However, if the user considers particular positions on the continuum, then he may feel that "low tinniness" is more like "solid" for him. The continuum therefore can be thought of as follows:

```
Tinny:      low                              high
            -------A----B-----------C---------
                  SOLID       TINNY
```

A is fairly solid (not at all tinny), C is tinny (not solid), and B is neither very tinny nor particularly solid—the user is indifferent. Working "up" a family tree (to the left) involves reflecting on how these adjective pairs relate to each other explicitly. Working "down" a family tree (to the right) involves reflecting on adjective pairs implicitly related to the ones explicitly labelled, possibly with a view to introducing new concepts into the structure. The basic similarity grouping produced earlier enables the user therefore both to identify anchor groups and also to ground concepts. To make this easier it uses a method which produces very tight groupings.

In the example, the user used the verbal analysis to reflect on underlying concepts associated within each of the groupings. Thus "soundness" identified for him the underlying pattern which came to mind when considering what he experienced when both "flexibility" and "good value" were present. Equally "engineered" underlay his experience of "well finished" and "well designed" when he considered the particular experiences. In each case, he could think of a concept, except for the combination of "bourgeois" and "extravagant", which he rejected: although he could think of a label, he did not feel that it had any meaning for him. The results of his reflections therefore were *anchor groups* identified as follows:

1. Bourgeois (I)
2. Extravagant (H)
3. Utilitarian (J)

Each one of these anchor groups corresponded to an area of related experiencing which made sense for the user as a whole, and which could be grounded on concepts which arose directly out of his experience of the experiences.

Each one of the concepts actually identified an adjective pair. Thus in the example the concepts were as follows:

comfortable	:	uncomfortable	/	comfortable
well finished	:	shoddily finished	/	well finished
well designed	:	botched	/	well designed
roomy	:	close fitting	/	roomy
good value	:	shoddy	/	good value
flexible	:	inflexible	/	flexible
costly to run	:	costly to run	/	cheap to run
different	:	run-of-the-mill	/	different
powerful	:	spongy	/	powerful
airy	:	claustrophobic	/	airy
easy to maintain	:	awkward	/	easy to maintain
robust	:	delicate	/	robust
tinny	:	tinny	/	solid

In some cases, the opposite was a simple negative (e.g. comfortable/uncomfortable) and in others it was a different word (e.g. solid/tinny). The reason for splitting the concepts, however, was to consider how each one felt when applied to the particular elements/experiences/options being considered. If a car was comfortable, the user would definitely prefer it to a car that was uncomfortable, *all other things being equal.* The same went for well finished and well designed cars. Close fitting cars, however, were not on reflection necessarily worse than roomy ones. The fact that the user did not feel a particular bias to either one or other of the "roomy" concepts suggested that it was not sufficiently grounded for this set of experiences. The technique for grounding "roomy" further therefore was as follows:

(1) split the concept into a pair;
(2) think of an opposite to each of the pair which is not the opposite in (1);
(3) decide whether you feel biased or not when considering the two pairs;
(4) if you still do not feel a bias, repeat this process (1–3) until you do.

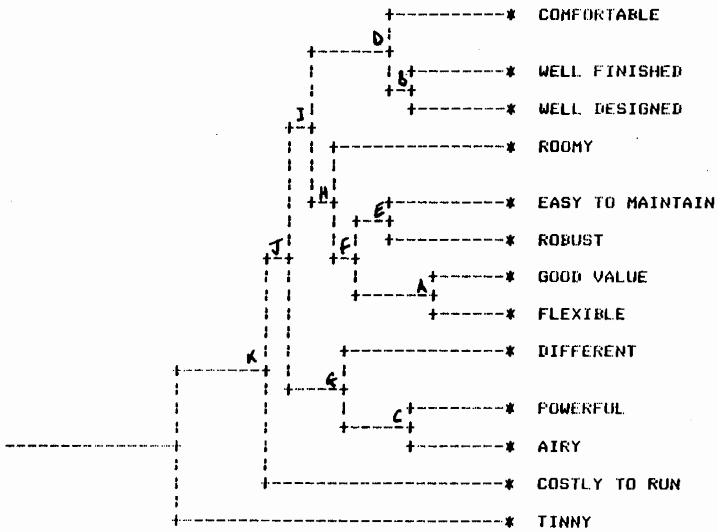
Applying this technique to "roomy" the user had:

roomy	:	boxlike	/	roomy
close fitting	:	cramped	/	close fitting

Both of these new pairs felt biased towards the right-handed one of the pair. The user could therefore introduce two new concepts and remove the old "roomy" in a new cycle of past reflection. As it happened the user felt biassed about all the other concepts, ("do-something-about-it" was on the left in the list and "that's-what-I-prefer" was on the right). Going through this process of defining pairs and splitting where necessary produced a *grounded* set of concepts.

```
ALTERNATIVES?
?YES
LATERAL GROUPING?
?YES
```

SIMILARITIES BASED ON LATERAL GROUPING:

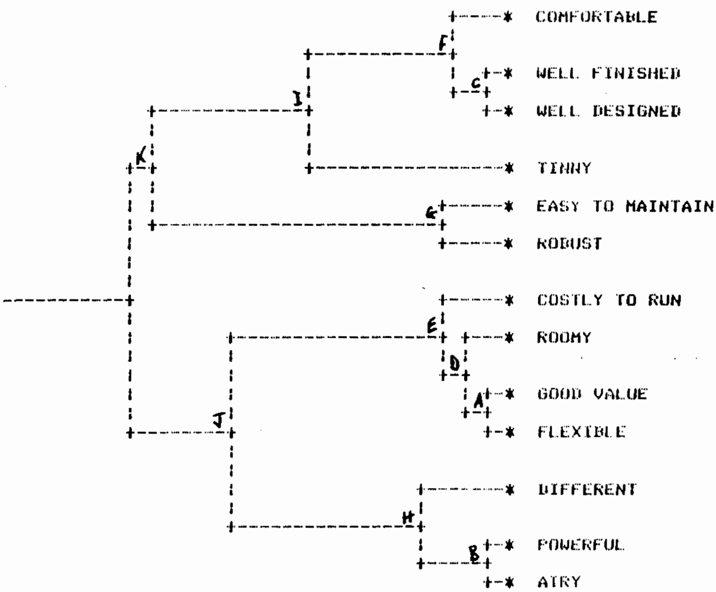



```
( 8) GOOD VALUE                AND FLEXIBLE                 => A[ SOUNDNESS   ]
(10) WELL FINISHED             AND WELL DESIGNED            => B[ ENGINEERED  ]
(10) POWERFUL                  AND AIRY                     => C[ SPORTY      ]
(10) COMFORTABLE               AND B[ ENGINEERED  ]         => D[ QUALITY     ]
(12) EASY TO MAINTAIN          AND ROBUST                   => E[ BASIC       ]
(15) E[ BASIC       ]          AND A[ SOUNDNESS   ]         => F[             ]
(16) DIFFERENT                 AND C[ SPORTY      ]         => G[ FLASH       ]
(17) ROOMY                     AND F[             ]         => H[             ]
(17) D[ QUALITY     ]          AND H[             ]         => I[             ]
(20) I[             ]          AND G[ FLASH       ]         => J[             ]
(22) J[             ]          AND COSTLY TO RUN            => K[             ]
```

These groups were looked at after the anchor groupings had begun to become clear. The program created groups by adding concepts to a particular group if a concept was closer to one of the concepts within that group than to any other concept or group of concepts. The effect of this method of grouping was therefore to leave outlying concepts until last. This is reflected in the shape of the family tree. "Tinny" and "costly to run" were both outliers to all of the groups, and "roomy" was an outlier to the "bourgeois" anchor group. These outlying concepts might have formed the basis of new anchor groups. By reflection therefore, and considering ways in which these outlying concepts were different, the base of the structure could be widened through the introduction of new concepts.

```
MORE ALTERNATIVES?
?YES
LATERAL GROUPING?
?NO
GROUPING IGNORING SCALING?
?YES
```

SIMILARITY GROUPING IGNORING SCALING:



(99)	GOOD VALUE	AND FLEXIBLE	=> A[SOUNDNESS]
(93)	POWERFUL	AND AIRY	=> B[SPORTY]
(93)	WELL FINISHED	AND WELL DESIGNED	=> C[ENGINEERED]
(91)	ROOMY	AND A[SOUNDNESS]	=> D[FAMILY]
(86)	COSTLY TO RUN	AND D[FAMILY]	=> E[ ]
(84)	COMFORTABLE	AND C[ENGINEERED]	=> F[QUALITY]
(84)	EASY TO MAINTAIN	AND ROBUST	=> G[BASIC]
(76)	DIFFERENT	AND B[SPORTY]	=> H[FLASH]
(49)	F[QUALITY]	AND TINNY	=> I[ ]
(26)	E[ ]	AND H[FLASH]	=> J[ ]
(7)	I[ ]	AND G[BASIC]	=> K[ ]

The final form of grouping was useful in making a normative statement based on the user's point of view after a well anchored, grounded and widely spread structure had been developed. The family tree created groups by ignoring the absolute rating positions on the dimensions, ignoring which way round the scale had been used, and using the same strong method of grouping as for the similarity grouping. The result therefore was a reduction in the number of groups, and an increase in the strength of association within the groups. (The program did this by using product moment correlations adjusted for element numbers, instead of mean absolute difference. The numbers in this case were therefore a measure of the probability of similarity.) The normative statement now resulted from considering which of the strong groupings included negatives. The car the user would buy had to be:

Comfortable, well finished and well designed;

not tinny;

easy to maintain and robust;

not costly to run, and roomy and good value
and flexible;

and different, powerful and airy.

This last statement was the statement which could form the basis of an option analysis. Option analysis could now be used to see how these concepts applied to future choices available to the user. The point in making the statement was not that it could not have been made before, but that it now had a much clearer *foundation* in the user's past experience, which he could better express.

The three different family trees therefore formed the basis for reflecting on the nature of core structure. This reflection had four aims:

(1) to identify *anchor groups* of concepts;
(2) to *ground* these groups of concepts;
(3) to *spread* the base of concepts as widely as possible;
(4) to make *normative* statements of preference arising out of the structure.

The result for the user was an increased ability to express core structure in relation to the particular problem.

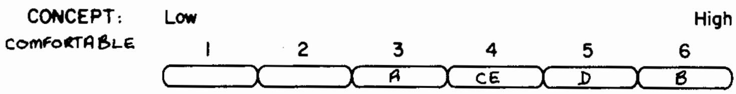
Reflective analysis

Reflective Analysis is a technique for examining a manager's subject-referenced knowledge, referred to as a whole as core structure. The key difference between subject-referenced and object-referenced knowledge lies in its psychological function for the manager. Object-referenced knowledge is "pre-emptive" and has an exclusive function: if a project costs £10,000, it does not cost £50,000. Subject-referenced knowledge is "propositional" and has a relational function: if a project is risky, it is risky relative to other projects. In order to analyse subject-referenced knowledge therefore, the technique analyses patterns of experiencing and how they are different. This is operationalised in the programs by the use of continua on which the managers can place letters representing object-referenced pre-emptions of their experience in relative positions, in order to express subject-referenced meaning. (This process can best be expressed mathematically through Fuzzy Subset Theory (Kaufmann, 1975), the set of experiences to be related being the "Reference Set", the experiences themselves being the "elements", and the relative positions along the continua being the "Membership Functions".) The programs then calculate differences between the patterns, and feed them back to the managers in various forms.

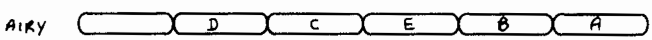
The technique of analysing differences can be explained in a very simple way using paper and pencil. Returning to the example of the cars, the set of experiences being related can be identified as follows:

A: TR4A
B: ROVER TC
C: FIAT 131
D: CITROEN GS
E: RENAULT 12
F:
etc.

In the programs, the continuum is mapped onto a number range 0–99. If instead the number range is 1–6, then the concept "comfortable" can be expressed as follows:



and similarly the concept "airy" can be expressed as:



The measure of difference used is the "Mean Absolute Difference" (the Relative Generalised Hamming Distance in Fuzzy Subset Theory), which is calculated by averaging the absolute difference in experience positions along or across continua. Thus the difference between "comfortable" and "airy" is calculated as follows:

$$(|3-6|+|6-5|+|4-3|+|5-2|+|4-4|)\div 5 = 1{\cdot}6.$$

The average distance between element positions over the two continua, and therefore the difference between the concepts, is 1·6 units, or $1{\cdot}6 \div 6 = 27\%$ of the continua as a whole. The difference between "TR4A" and "CITROEN GS" is calculated in a similar way:

$$(|3-5|+|6-2|)\div 2 = 3.$$

The average difference between "TR4A" and "CITROEN GS" being 3 units, or $3 \div 6 = 50\%$ of the continua. The essential reason for using this measure of difference is therefore not just that it is transparent to the manager, but also because its meaning is directly relatable by the manager back to the meanings which he was expressing on the original continua. This is a necessary condition for supporting reflective learning.

PAST REFLECTION

The process of Past Reflection has already been dealt with in some detail. Its purpose was to enable the manager to explore how he valued past experience which he felt was relevant to a current problem and its context. The program allows the manager to go on adding and deleting concepts and experiences until he is satisfied that he is reflecting on a whole.

```
MORE ALTERNATIVES?
?NO
FINISH?
?NO
DELETE CONCEPTS?
?NO
ADD CONCEPTS?
?NO
INVERT CONCEPTS?
?NO
DELETE EXPERIENCES?
?NO
ADD EXPERIENCES?
?NO
DATA LISTING?
?NO
EXPERIENCE DIFFERENCE?
?NO
CONCEPT SIMILARITY?
?NO
```

The capacity to invert concepts allows him to reverse the value implications of left–right on a continuum. Finally when he has finished, the program prints out its internal representation of the element positions on the continua, and allows him to delete his data if for whatever reason he does not wish to leave it in the computer.

```
FINISH?
?YES


1      TR4A
2      ROVER TC
3      FIAT 131
4      CITROEN GS
5      RENAULT 12

        1   2   3   4   5

1      41  89  47  69  45    COMFORTABLE
2      93  47  61  69  53    COSTLY TO RUN
3      21  81  63  79  93    ROOMY
4      93  63  19  45  15    DIFFERENT
5      41  95  17  77  59    WELL FINISHED
6      49  35  43   9  79    EASY TO MAINTAIN
7      15  65  35  45  81    GOOD VALUE
8      39  53  29  19  73    ROBUST
9      27  63  47  53  75    FLEXIBLE
10     15   7  87  23  37    TINNY
11     49  91  19  63  39    WELL DESIGNED
12     99  79  53  21  35    POWERFUL
13     91  71  33  19  47    AIRY


DATA DELETED?
?NO
```

OPTION ANALYSIS

```
FORMS FOR REMOTE USE?
?NO
PAST REFLECTION?
?NO
OPTION ANALYSIS?
?YES
HP2640 TERMINAL?
?NO
```

Option Analysis enables the manager to consider how his concepts of value are influencing his view of the choices presently open to him for acting on a problem. This can be done with the concepts produced by Past Reflection, or as in this case with a subset of those concepts which the manager feels are particularly important.

```
                         OPTION ANALYSIS
                         ***************

                PLEASE ENTER IDENTITY CODE ? 4
                DATA ON FILE?
                ?NO
                DATA FROM PAST REFLECTION?
                ?NO
                HOW MANY EVALUATIVE CONCEPTS?
                ?7
                ENTER 7     20 CHARACTER LABELS FOR THEM
                < QUALITY
                < FAMILY
                < SOUND
                < BASIC
                < EXTRAVAGANT
                < SPORTY
                < TINNY
                HOW MANY OPTIONS ARE YOU CONSIDERING?
                ?5
                ENTER 5     20 CHARACTER LABELS FOR THEM
                < AUSTIN MAXI
                < RENAULT 12
                < CITROEN GS
                < PEUGEOT 304
                < FIAT 131
```

The manager can then evaluate each option in terms of each concept.

```
WHEN RATING THE ELEMENTS AGAINST EACH CONCEPT
USE LETTERS TO REPRESENT THE ELEMENTS AS FOLLOWS:-
          a - AUSTIN MAXI                b - RENAULT 12
          c - CITROEN GS                 d - PEUGEOT 304
          e - FIAT 131



                    LOW                                                 HIGH
QUALITY             !_____________________________________________________!
ABCDE               ?     E           A      D    B            C

QUALITY             !_____e___________a______d____b____________c__________!
OK ? YES




FAMILY              !---------------e---d----------c---------a-------b------!

SOUND               !--------c----e--a-------------d-----b-------------!

BASIC               !---------e----c---a-----------d-------b-------------!

EXTRAVAGANT         !---------a----b------------c----d----------e----------!

SPORTY              !--------ba---d----------c-------------e----------------!

TINNY               !---------------d--a---------c---b-------e-------------!
```

From these evaluations the program can then analyse both which options are experienced as similar, and also which concepts express values which pattern the options in similar ways.

```
OPTION ANALYSIS?
?YES

OPTION GROUPINGS:

                           +-------------------*  AUSTIN MAXI
                         +-+
                         I +-------------------*  RENAULT 12
       +-----------------+
       I                 I
       I                 +---------------------*  PEUGEOT 304
-------+
       I
       I               +-----------------------*  CITROEN GS
       +---------------+
                       +-----------------------*  FIAT 131


SORT OPTION SEQUENCE?
?YES


CONCEPT GROUPINGS:

                        +-----------------------*  QUALITY
                        I
                      +-+
                      I I                 +---*  SOUND
                      I +-----------------+
          +-----------+                   +---*  BASIC
          I           I
          I           I
          I           +-------------------------*  FAMILY
----------+
          I                     +---------*  EXTRAVAGANT
          I               +-----+
          I               I     +---------*  SPORTY
          +---------------+
                          I
                          +---------------*  TINNY


SORT CONCEPT SEQUENCE?
?YES
```

From this analysis it can be seen that the Citroen and Fiat are a different kind of option to the other three cars; and that the concepts break into two main groups, one perhaps associated with a liking for speed, and the other with the need for a general purpose family car. The way in which the concepts are grouping the options can then be seen as a result of the sorting:

```
PATTERN ANALYSIS OF OPTION PREFERENCES:

1      AUSTIN MAXI
2      RENAULT 12
3      PEUGEOT 304
4      CITROEN GS
5      FIAT 131


         1    2    3    4    5

1        -    +    +  | ++   --     QUALITY
2        -   ++    +  | --    -     SOUND
3        -   ++    +  |  -   --     BASIC
4        +   ++    -  |  +   --     FAMILY
        --------------+----------
5       --    -    +  |  +   ++     EXTRAVAGANT
6        -    -    -  |  +   ++     SPORTY
7        -    +   --  |  +   ++     TINNY
```

The analysis shows that the "extravagant", "sporty" and "tinny" cars are the Citroen and Fiat, and that none of the other cars satisfy these values, whereas all the other cars do satisfy the general-purpose family car values.

```
FINISH?
?NO
DELETE OPTIONS?
?NO
ADD OPTIONS?
?NO
DELETE CONCEPTS?
?NO
ADD CONCEPTS?
?NO
INVERT CONCEPTS?
?NO
DATA LISTING?
?NO
OPTION ANALYSIS?
?NO
```

The manager can go on to consider trade-offs and weightings, adding and deleting concepts and options until he is satisfied that he understands exactly what he will gain and lose as a result of pursuing each option or group of options.

```
FINISH?
?YES

1      AUSTIN MAXI
2      RENAULT 12
3      CITROEN GS
4      PEUGEOT 304
5      FIAT 131

         1    2    3    4    5

1       33   55   79   45   11    QUALITY
2       75   89   59   39   31    FAMILY
3       33   73   17   63   27    SOUND
4       37   75   29   61   19    BASIC
5       17   27   51   61   79    EXTRAVAGANT
6       19   17   47   27   71    SPORTY
7       35   61   53   29   75    TINNY

DATA DELETED?
?NO
```

CONCEPT ANALOGIES

```
FORMS FOR REMOTE USE?
?NO
PAST REFLECTION?
?NO
OPTION ANALYSIS?
?NO
CONCEPT ANALOGIES?
?YES
HP2640 TERMINAL?
?NO
```

The manager may feel that he has got locked into a particular view of the problem, and that if he were able to talk it over with another manager, he might gain a different perspective. Concept Analogies supports this process, by allowing the manager with the problem to explain it to another manager so that the other manager can use his concepts for evaluating the options. Depending on the skill of the other manager in thinking analogously, his concepts will be more or less directly related to the problem. The importance for the manager with the problem however will be the process of thinking about his own problem through the other manager's eyes.

```
          CONCEPT ANALOGIES
          *****************

PLEASE ENTER IDENTITY CODE ? 4
DO YOU KNOW THE OTHER PERSON'S IDENTITY CODE?
?NO
HIS NUMBER IS OPPOSITE HIS NAME:
 1    RICHARD
 2    ANDREW
 3    CLODAGH
 4    PHILIP
ENTER HIS IDENTITY CODE:
?1
ARE YOU CONSIDERING YOUR OWN OPTIONS(1)
OR ANOTHER PERSON'S OPTIONS(2) ?
?1
DATA ON FILE?
?NO


ESTIMATE HOW THE OTHER PERSON HAS EVALUATED YOUR OPTIONS:
WHEN RATING THE ELEMENTS AGAINST EACH CONCEPT
USE LETTERS TO REPRESENT THE ELEMENTS AS FOLLOWS:-
          a - AUSTIN MAXI                 b - RENAULT 12
          c - CITROEN GS                  d - PEUGEOT 304
          e - FIAT 131

                    LOW                                            HIGH
FUN                 !______________________________________________!
XBEBK               ?      A       B       D      E         C

FUN                 !_________a_______b______d_____e__________c___!
OK ? Y


CAMPING             !---------------e----------d-a-b-------c-----------!

ME                  !---------a--d---e-----------------b----c-----------!

COMFORT             !---------------------d----b-----a------e-c----------!

STAID               !-------c-------b------e-----------------d--------a----!

CHEAP TO RUN        !--------------------e----------d----c-a--b--------!

LASTING             !----------------------e--------d---------a-bc-------!

SOLID               !---------------c-----e--d-------b-----a--------------!

EASY TINKER         !---------c------------d-e--------b---a--------------!
```

Assuming that the other manager has done his bit, then the manager with the problem will be able to use the program to analyse how close he has got to the other manager's point of view in trying to get outside his own.

```
HAS THE OTHER PERSON EVALUATED YOUR OPTIONS?
?YES
ANALYSIS OF ESTIMATES?
?YES


% INACCURACY OF ESTIMATES (0=VERY GOOD):


                    FUN                      : 15
                    CAMPING                  : 20
                    ME                       : 22
                    COMFORT                  : 24
                    STAID                    : 48
                    CHEAP TO RUN             : 31
                    LASTING                  : 46
                    SOLID                    : 27
                    EASY TINKER              : 24
```

He will also be able to examine how his use of the other manager's concepts (in brackets) relate to his own concepts.

```
COMPARISON WITH OWN CONCEPTS?
?YES

COMPARISON WITH YOUR OWN CONCEPTS:

                               +--------------*  FUN
                               |
                  +------------+
                  |            |    +---------* (EXTRAVAGANT)
                  |            +----+
                  |                 +---------* (SPORTY)
                  |
                  |
           +------+                +----------*  CAMPING
           |      |              +-+
           |      |              | +----------* (QUALITY)
           |      |        +-----+
           |      |        |     |
           |      |        |     +------------*  ME
           |      +--------+
           |               |
           |               |      +-----------*  COMFORT
           |               +------+
-----------+                      +-----------* (TINNY)
           |
           |                   +--------------*  STAID
           |                   |
           |         +---------+
           |         |         |         +----*  SOLID
           |         |         +---------+
           |         |                   +----*  EASY TINKER
           |         |
           |         |
           +---------+                    +---*  CHEAP TO RUN
                     |            +-------+
                     |            |       +---*  LASTING
                     | +----------+
                     | |          |
                     | |          +-----------* (FAMILY)
                     +-+
                       |
                       |                 +----* (SOUND)
                       +-----------------+
                                         +----* (BASIC)
```

This analysis can enable him to work on understanding the other manager's view and then to go back to Option Analysis to incorporate any new concepts which may have come to mind as a result of the process.

```
ALTERNATIVES?
?YES
LATERAL GROUPING?
?NO
GROUPING IGNORING SCALING?
?NO
MORE ALTERNATIVES?
?NO



FINISH?
?NO
MODIFY ESTIMATES?
?NO
DATA LISTING?
?NO
ANALYSIS OF ESTIMATES?
?NO
GROUPING OF ESTIMATES WITH HIS ACTUAL EVALUATIONS?
?NO
COMPARISON WITH OWN CONCEPTS?
?NO



FINISH?
?YES



1     AUSTIN MAXI
2     RENAULT 12
3     CITROEN GS
4     PEUGEOT 304
5     FIAT 131



        1    2    3    4    5

1      19   37   91   53   67    FUN
2      59   63   77   55   33    CAMPING
3      19   67   77   25   33    ME
4      63   53   79   43   75    COMFORT
5      91   29   15   73   41    STAID
6      77   83   73   63   43    CHEAP TO RUN
7      79   83   85   61   47    LASTING
8      71   61   30   46   40    SOLID
9      71   63   18   42   46    EASY TINKER



DATA DELETED?
?NO
```

ROLE NETWORK ANALYSIS

```
FORMS FOR REMOTE USE?
?NO
PAST REFLECTION?
?NO
OPTION ANALYSIS?
?NO
CONCEPT ANALOGIES?
?NO
ROLE NETWORK ANALYSIS?
?YES
HP2640 TERMINAL?
?NO
```

So far programs have been described which help the individual manager to know his own value perspective as clearly as possible. The process of Consensus Generation assumes that a group of managers are interdependent: any action taken by any one of them will affect or constrain the actions open to any other. Role Network Analysis provides a means of examining the diversity of perspective and the extent to which each manager appreciates that diversity. To do this a set of options are needed which can form a benchmark for the analysis.

```
ROLE NETWORK ANALYSIS
*********************



FILES SET UP?
?NO
ARE YOU SURE!
?YES
HOW MANY PEOPLE IN NETWORK?
?4
ENTER A 20 CHARACTER NAME FOR EACH OF THE 4     PEOPLE
< RICHARD
< ANDREW
< CLODAGH
< PHILIP
HOW MANY OPTIONS?
?6
ENTER 4     20 CHARACTER LABELS FOR THEM
< RENAULT 12
< RENAULT 14
< CITROEN GS
< AUSTIN MAXI
< PEUGEOT 304
< FIAT 131
DO YOU KNOW YOUR IDENTITY NUMBER?
?NO
YOUR NUMBER IS OPPOSITE YOUR NAME!
 1     RICHARD
 2     ANDREW
 3     CLODAGH
 4     PHILIP
PLEASE ENTER IDENTITY CODE ? 4
DATA ON FILE?
?NO
```

Each manager estimates the preferences each other manager has for the options,

```
OPPOSITE YOUR OWN NAME RATE YOUR PREFERENCES FOR
THE OPTIONS; AND OPPOSITE THE OTHERS' NAMES, ESTIMATE
THE OTHERS' PREFERENCES.


WHEN RATING THE ELEMENTS AGAINST EACH CONCEPT
USE LETTERS TO REPRESENT THE ELEMENTS AS FOLLOWS:-
          a - RENAULT 12                b - RENAULT 14
          c - CITROEN GS                d - AUSTIN MAXI
          e - PEUGEOT 304               f - FIAT 131



                   LOW                                               HIGH
RICHARD            !----------------------------------------------------!
[redacted]         ?      D     F  A E          B            C

RICHARD            !------d-----f--a-e----------b------------c----------!
OK ? YES



                   LOW                                               HIGH
ANDREW             !----------------------------------------------------!
[redacted]         ?      A   D   C     B   E       F

ANDREW             !------a---d---c-----b---e-------f-------------------!
OK ? Y



                   LOW                                               HIGH
CLODAGH            !----------------------------------------------------!
[redacted]         ?     DA      F        B     C        E

CLODAGH            !-----da------f--------b-----c--------e--------------!
OK ? Y
```

and also defines his own preferences:

```
                   LOW                                               HIGH
PHILIP             !----------------------------------------------------!
[redacted]         ? D          B      E     F    C   A

PHILIP             !--d---------b------e-----f----c---a-----------------!
OK ? NO            ?      D

PHILIP             !------d-----b------e-----f----c---a-----------------!
OK ? YES
```

From this data the program can then analyse which managers' actual views are similar, and the extent to which each manager's views are different from each other manager.

```
DATA ANALYSIS?
?YES
ON EVERYONE IN NETWORK?
?YES


          ANALYSIS OF ACTUAL PREFERENCES:

ACTUAL SIMILARITIES BETWEEN PEOPLE IN NETWORK:

                        +------------------------* RICHARD
      +-----------------+
      !                 +------------------------* ANDREW
-----+
      !          +-------------------------------* CLODAGH
      +----------+
                 +-------------------------------* PHILIP


 ACTUAL DIFFERENCES BETWEEN THEIR POINTS OF VIEW:


            a - RICHARD                      b - ANDREW
            c - CLODAGH                      d - PHILIP

                      LOW                                                    HIGH

 RICHARD              !a---------b-d----c-------------------------------------!

 ANDREW               !b---------a------c-d-----------------------------------!

 CLODAGH              !c-------------d--ab------------------------------------!

 PHILIP               !d-----------a-c----b-----------------------------------!
```

This analysis can provide important insights into the degree of difference which the group will have to come to terms with if it is to arrive at a consensus view. It is important to realise however that any consensus will have to be arrived at not by removing the differences, but rather by finding ways of understanding and working with the differences. The second part of the analysis provides each manager with an assessment of how accurately he has estimated the others' views.

```
ANALYSIS OF ESTIMATES?
?YES


YOUR ESTIMATE OF THEIR SIMILARITIES :
                  +---------------------------* RICHARD
     +------------+
     !            +---------------------------* CLODAGH
-----+
     !  +-------------------------------------* ANDREW
     +--+
        +-------------------------------------* PHILIP

% INACCURACY OF YOUR ESTIMATES (0=VERY GOOD):


                   RICHARD           : 16
                   ANDREW            : 36
                   CLODAGH           : 20
                   PHILIP            : 0
```

This both can show how the manager thinks people are grouped, and also can give him some measure of who he misunderstands the most. Assuming that the other managers have also worked on their respective value perspectives reflectively, then this analysis can indicate who to work with in Exchanging Views.

```
FINISH?
?NO
MODIFY ESTIMATES?
?NO
DATA LISTING?
?NO
DATA ANALYSIS?
?NO

FINISH?
?YES
```

```
1     RENAULT 12
2     RENAULT 14
3     CITROEN GS
4     AUSTIN MAXI
5     PEUGEOT 304
6     FIAT 131


        1   2   3   4   5   6

1      31  55  81  13  35  25   RICHARD
2      13  41  29  21  49  65   ANDREW
3      13  43  55  11  73  27   CLODAGH
4      69  25  61  13  39  51   PHILIP


DATA. DELETED?
?NO
```

EXCHANGING VIEWS

```
FORMS FOR REMOTE USE?
?NO
PAST REFLECTION?
?NO
OPTION ANALYSIS?
?NO
CONCEPT ANALOGIES?
?NO
ROLE NETWORK ANALYSIS?
?NO
EXCHANGING VIEWS?
?YES
HP2640 TERMINAL?
?NO
```

Exchanging Views can provide a means of exploring how another manager evaluates options common to both managers, and of providing a detailed analysis of how the views are different.

```
                EXCHANGING VIEWS
                ****************

PLEASE ENTER IDENTITY CODE ? 4
DO YOU KNOW THE OTHER PERSON'S IDENTITY CODE?
?NO
HIS NUMBER IS OPPOSITE HIS NAME:
 1     RICHARD
 2     ANDREW
 3     CLODAGH
 4     PHILIP
ENTER HIS IDENTITY CODE:
?1
DATA ON FILE?
?NO
THESE ARE YOUR OWN OPTIONS:
 1     AUSTIN MAXI
 2     RENAULT 12
 3     CITROEN GS
 4     PEUGEOT 304
 5     FIAT 131
AND THESE ARE THE OTHER PERSON'S OPTIONS:
 1     MAXI
 2     REN 12
 3     REN 14
 4     CIT GS
 5     PEU 304
 6     DYANE
ENTER THE NUMBERS OF THE OPTIONS OF THE OTHER PERSON WHICH
YOU WANT TO USE FOR ESTIMATING (ONE PER LINE, 0=FINISH)
?1
?2
?4
?5
?0
 1     MAXI
 2     REN 12
 3     CIT GS
 4     PEU 304
ARE THEY CORRECT?
?YES
```

The manager chose to exchange views with Richard, although his misunderstanding of Andrew's views was greater. To do this he estimated how the other manager used his concepts.

```
NOW ESTIMATE THE OTHER PERSON'S PREFERENCES
WHEN RATING THE ELEMENTS AGAINST EACH CONCEPT
USE LETTERS TO REPRESENT THE ELEMENTS AS FOLLOWS:-
          a - MAXI                        b - REN 12
          c - CIT GS                      d - PEU 304

                    LOW                                                HIGH
FUN                 :--------------------------------------------------:
XXXX                ?   A         D  B                         C

FUN                 :----a---------d--b----------------------------c-------:
OK ? YES


CAMPING             :---------------d--a-------------b-----------c---------:

ME                  :--a-----b---------------d----------------c-----------:

COMFORT             :--------------a----b--------------d---------c--------:

STAID               :----------c----------d-------------------b----a-------:

CHEAP TO RUN        :-------a----------c------d-------------------b--------:

LASTING             :----------a--------d-------------b-------------c-------:

SOLID               :----------c----------b-------a------------d-----------:

EASY TINKER         :---c---------------------d-------a--------b-----------:
```

On the basis of these estimates, the program can analyse the accuracy with which the manager has estimated each concept.

```
ANALYSIS OF ESTIMATES?
?YES

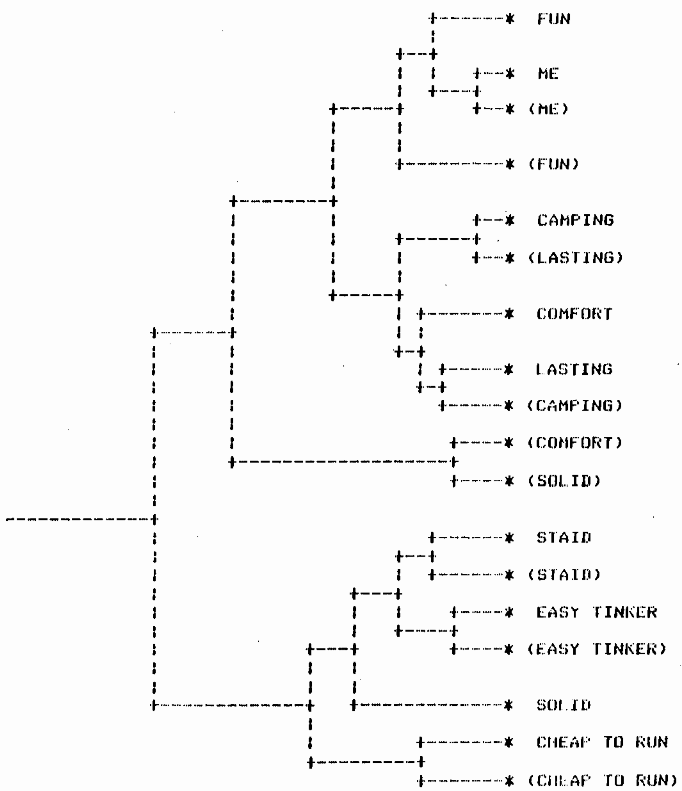

% INNACURACY OF YOUR ESTIMATES (0=VERY GOOD):


                     FUN              : 17
                     CAMPING          : 14
                     ME               : 6
                     COMFORT          : 20
                     STAID            : 13
                     CHEAP TO RUN     : 14
                     LASTING          : 12
                     SOLID            : 26
                     EASY TINKER      : 9
```

The numbers indicate which concepts have been most misunderstood. The program can also show the manager how his estimates relate to the other manager's actual use of his concepts:

```
GROUPING OF ESTIMATES WITH HIS ACTUAL PREFERENCES?
?YES


ESTIMATED AND ACTUAL PREFERENCE GROUPINGS:
```



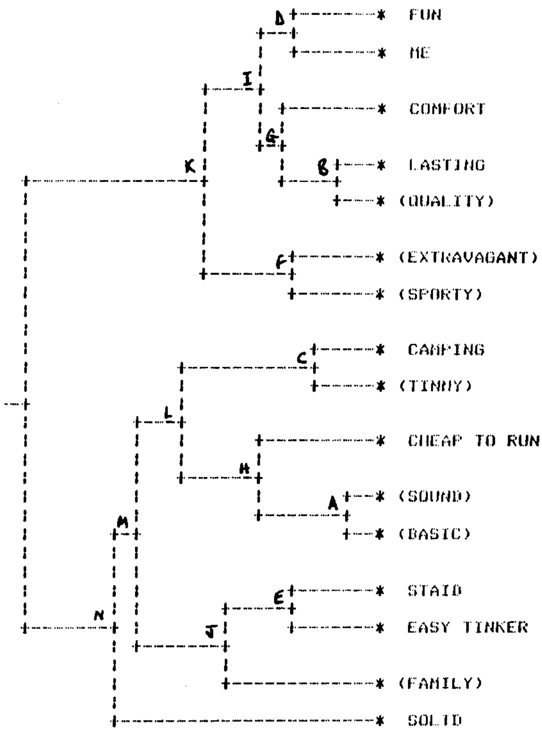
Richard's actual concepts are in brackets, and the manager's estimates using his concepts are not. This information can provide additional insights into how the manager is missing the other's point of view. Dealing with these misunderstandings enables the manager to gain an understanding of the other's view which takes him beyond his own. By then relating those new concepts back to his own, the manager can begin to develop a language for expressing how their different views relate.

```
COMPARISON WITH OWN CONCEPTS?
?YES
THESE ARE THE OPTIONS YOU USED FOR ESTIMATION:
 1     MAXI
 2     REN 12
 3     CIT GS
 4     PEU 304
THESE ARE YOUR OWN OPTIONS:
 1     AUSTIN MAXI
 2     RENAULT 12
 3     CITROEN GS
 4     PEUGEOT 304
 5     FIAT 131
ENTER THE NUMBERS OF YOUR OWN OPTIONS WHICH CORRESPOND
TO THE ONES USED FOR ESTIMATION. (ONE PER LINE 0=FINISH)
?1
?2
?3
?4
?0
 1     AUSTIN MAXI
 2     RENAULT 12
 3     CITROEN GS
 4     PEUGEOT 304
ARE THEY CORRECT?
?YES
```

```
COMPARISON WITH YOUR OWN CONCEPTS:

( 5) (SOUND)                 AND (BASIC)                 => A[ PRACTICAL      ]
( 5) LASTING                 AND (QUALITY)               => B[ QUALITY        ]
( 9) CAMPING                 AND (TINNY)                 => C[ UTILITARIAN    ]
(12) FUN                     AND ME                      => D[ FEELS GOOD     ]
(12) STAID                   AND EASY TINKER             => E[ TRADITIONAL    ]
(12) (EXTRAVAGANT)           AND (SPORTY)                => F[ EXTRAVAGANT    ]
(13) COMFORT                 AND B[ QUALITY        ]     => G[ LUXURIOUS      ]
(16) CHEAP TO RUN            AND A[ PRACTICAL      ]     => H[ GOOD VALUE     ]
(17) D[ FEELS GOOD     ]     AND G[ LUXURIOUS      ]     => I[ IDEAL          ]
(22) E[ TRADITIONAL    ]     AND (FAMILY)                => J[ SAFE BET       ]
(25) I[ IDEAL          ]     AND F[ EXTRAVAGANT    ]     => K[ ——             ]
(28) C[ UTILITARIAN    ]     AND H[ GOOD VALUE     ]     => L[ SENSIBLE       ]
(34) L[ SENSIBLE       ]     AND J[ SAFE BET       ]     => M[ ——             ]
(36) M[                ]     AND SOLID                   => N[ ——             ]
```

Again the manager can work through the concepts reflectively, relating the individual concepts to the structure as a whole, so that the two managers have some basis for discussing what form an option commanding consensus support might take.




```
ALTERNATIVES?
?YES
LATERAL GROUPING?
?NO
GROUPING IGNORING SCALING?
?NO
MORE ALTERNATIVES?
?NO

 FINISH?
 ?YES

 1      MAXI
 2      REN 12
 3      CIT GS
 4      PEU 304


          1    2    3    4

 1        9   35   87   29     FUN
 2       37   63   85   31     CAMPING
 3        5   15   79   45     ME
 4       29   39   81   63     COMFORT
 5       85   75   21   43     STAID
 6       15   87   35   47     CHEAP TO RUN
 7       19   55   79   37     LASTING
 8       53   39   19   71     SOLID
 9       61   79    7   51     EASY TINKER

YOUR CORRESPONDING OPTIONS WERE:
 1      AUSTIN MAXI
 2      RENAULT 12
 3      CITROEN GS
 4      PEUGEOT 304


DATA DELETED?
?NO
```

CONSENSUS GROUPING

```
FORMS FOR REMOTE USE?
?NO
PAST REFLECTION?
?NO
OPTION ANALYSIS?
?NO
CONCEPT ANALOGIES?
?NO
ROLE NETWORK ANALYSIS?
?NO
EXCHANGING VIEWS?
?NO
CONSENSUS GROUPING?
?YES
HP2640 TERMINAL?
?NO
```

At the end of a process of Consensus Generation, a group of managers will have developed a language for discussing how their different views relate to each other. This will not have removed the differences, but will have given the managers a way of working with their differences. Consensus Grouping like Option Analysis is concerned with exploring the trade-offs between those differences when different courses of action are considered. The courses of action may be represented by one or more options, but taken together, they will represent different strategies for dealing with the problem, assuming that there is some feasible way of implementing the options. It is for this reason that these processes of Consensus Grouping and Option Analysis are referred to as Strategic Design.

```
          CONSENSUS GROUPING
          ******************

PLEASE ENTER IDENTITY CODE ? 4
DATA ON FILE?
?NO
THESE ARE THE PEOPLE IN THE NETWORK:
 1     RICHARD
 2     ANDREW
 3     CLODAGH
 4     PHILIP
THE OPTIONS USED BY THE FOLLOWING PEOPLE ARE:
PERSON 1      :
 1     MAXI
 2     REN 12
 3     REN 14
 4     CIT GS
 5     PEU 304
 6     DYANE
PERSON 2      :
PERSON 3      :
PERSON 4      :
 1     AUSTIN MAXI
 2     RENAULT 12
 3     CITROEN GS
 4     PEUGEOT 304
 5     FIAT 131
DECIDE WHICH PEOPLE YOU WANT TO INCLUDE IN THE
CONSENSUS GROUPING, AND CHOOSE OPTIONS WHICH ARE
COMMON TO ALL OF THEM.   HOW MANY OPTIONS?
?4
ENTER 4     20 CHARACTER LABELS FOR THEM(ONE PER LINE)
< MAXI
< REN 12
< CIT GS
< PEU 304
```

```
WHOSE CONCEPTS DO YOU WANT TO TRANSFER? (0=NO MORE)
?1
ENTER THE NUMBERS OF THE OTHER PERSON'S OPTIONS WHICH
CORRESPOND TO THE ONES IN THE COMMON SET;
(ONE PER LINE 0=FINISH)
?1
?2
?4
?5
?0
 1     MAXI
 2     REN 12
 3     CIT GS
 4     PEU 304
ARE THEY CORRECT?
?YES
THESE ARE HIS CONCEPTS:
 1     FUN
 2     CAMPING
 3     ME
 4     COMFORT
 5     STAID
 6     CHEAP TO RUN
 7     LASTING
 8     SOLID
 9     EASY TINKER
DO YOU WANT TO TRANSFER ALL OF THEM?
?YES


WHOSE CONCEPTS DO YOU WANT TO TRANSFER? (0=NO MORE)
?4
ENTER THE NUMBERS OF THE OTHER PERSON'S OPTIONS WHICH
CORRESPOND TO THE ONES IN THE COMMON SET;
(ONE PER LINE 0=FINISH)
?1
?2
?3
?4
?0
 1     AUSTIN MAXI
 2     RENAULT 12
 3     CITROEN GS
 4     PEUGEOT 304
ARE THEY CORRECT?
?YES
THESE ARE HIS CONCEPTS:
 1     QUALITY
 2     FAMILY
 3     SOUND
 4     BASIC
 5     EXTRAVAGANT
 6     SPORTY
 7     TINNY
DO YOU WANT TO TRANSFER ALL OF THEM?
?YES
```

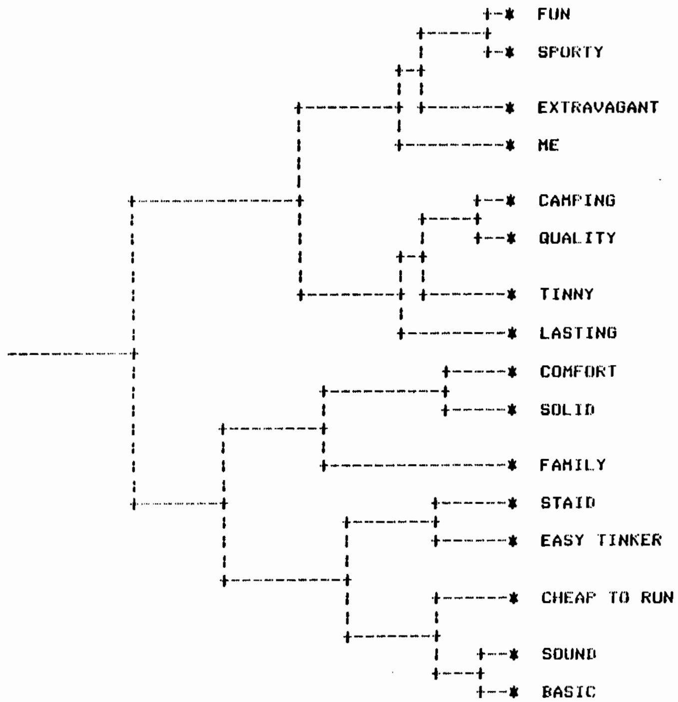
The analysis which can be done is identical to Option Analysis, so that the options and concepts can again be grouped, and the relationship between the two explored:

```
WHOSE CONCEPTS DO YOU WANT TO TRANSFER? (0=NO MORE)
?0
CONSENSUS GROUPING?
?YES

CATEGORIES OF OPTION:
                          +--------------------* MAXI
                          !
         +----------------+
         !                ! +------------------* REN 12
         !                +-+
  -------+                  +------------------* PEU 304
         !
         !
         +-------------------------------------* CIT GS


SORT OPTION SEQUENCE?
?YES
```

CATEGORIES OF CONCEPT:



SORT CONCEPT SEQUENCE?
?<u>YES</u>

PATTERN ANALYSIS OF THE COLLECTED OPTION PREFERENCES:

1 MAXI
2 REN 12
3 PEU 304
4 CIT GS

	1	2	3	4	
1	-	-	+	++	FUN
2	-	-	-	++	SPORTY
3	--	-	++	+	EXTRAVAGANT
4	-	-	+	++	ME
5	--	+	-	++	CAMPING
6	--	+	-	++	QUALITY
7	-	++	--	+	TINNY
8	-	+	--	++	LASTING
9	+	--	-	++	COMFORT
10	+	--	-	++	SOLID
11	+	++	--	-	FAMILY
12	+	+	+	--	STAID
13	+	+	+	--	EASY TINKER
14	--	+	+	-	CHEAP TO RUN
15	-	++	+	--	SOUND
16	-	++	+	--	BASIC

This analysis only shows two managers' views combined. Adding the other two's views might make the trade-offs more polarised, or create new possibilities for compromise, but the Consensus Grouping would always represent a picture of the trade-offs between the managers. At one extreme it might show options which everyone valued; or at the other how the gains of one group of managers would be the losses of another. Either way, its usefulness lies in the purchase it can give individual managers on what trade-offs have to be negotiated between them, and where new options need to be created in order to create a basis for compromise. The technique is therefore a means of securing more effective action, by providing support for a process of integrative bargaining (Walton & McKersie, 1966).

```
FINISH?
?NO
CONSENSUS GROUPING?
?NO
DELETE CONCEPTS?
?NO
DELETE OPTIONS?
?NO
ADD OPTIONS?
?NO
ADD MORE CONCEPTS?
?NO
DATA LISTING?
?NO

FINISH?
?YES

1    MAXI
2    REN 12
3    CIT GS
4    PEU 304
```

	1	2	3	4	
1	15	17	43	29	FUN
2	31	51	67	49	CAMPING
3	15	17	89	43	ME
4	77	27	91	53	COMFORT
5	81	85	31	71	STAID
6	23	63	41	65	CHEAP TO RUN
7	39	53	89	23	LASTING
8	79	45	89	69	SOLID
9	67	77	9	75	EASY TINKER
10	33	55	79	45	QUALITY
11	75	89	59	39	FAMILY
12	33	73	17	63	SOUND
13	37	75	29	61	BASIC
14	17	27	51	61	EXTRAVAGANT
15	19	17	47	27	SPORTY
16	35	61	53	29	TINNY

```
DATA DELETED?
?NO
```

```
FINISH?
?NO
PAST REFLECTION?
?NO
OPTION ANALYSIS?
?NO
CONCEPT ANALOGIES?
?NO
ROLE NETWORK ANALYSIS?
?NO
EXCHANGING VIEWS?
?NO
CONSENSUS GROUPING?
?NO
FINISH?
?YES
DONE
```

This section has shown how the technique of Reflective Analysis can be used to explore subject-referenced knowledge in relation to a particular problem and its context. One assumption which has been made throughout about the problem itself is that there do exist clear options. There is no reason why this should be the case, since the problem and its context are quite likely to be as undefined as the manager's awareness of his own values. The method of structural analysis (Boxer, 1979) complements Reflective Analysis since it enables managers to analyse and experience how actions taken in their task environment will interact with each other. This process would thus be one way of clarifying options in the task environment. Such a process must necessarily complement any use of Reflective Analysis with the manager if the manager is to produce benefit for his organisation as well as for himself.

Conclusion

The software developed by the Management Decision-making Project and referred to as "NIPPER" defined a programming language useful in supporting reflective learning. The six programs described in this paper were developed by the author for a particular purpose, and as such represent only one out of an unlimited number of ways of using "NIPPER" (Boot, 1979). The programs were developed for managers likely to have the greatest difficulty in keeping espoused theories and theories-in-use congruent: managers in complex organisations who are concerned with managing structural change, and who work with a high degree of functional specialisation and inter-dependency in their organisation's activities. Such managers are likely to have such difficulty because the nature of their organisation forces them to act so much through their use of language rather than to act directly on the task environment.

The theory underlying the use of this method explains why the manager is likely to have difficulty expressing concepts of value and relatedness: the structure implicit in his use of language is heavily biassed towards the expression of object-referenced knowledge. Through its tendency towards pre-emptiveness and exclusivity therefore, his language makes it difficult for the manager to talk about context and the value of his past experience. The theory points towards the need for a change in the way managers use language so that such meanings can more easily be expressed. This paper describes one way of enabling managers to learn to make that change: when they choose. The method described in this paper therefore enables the manager to learn not only to value his own experience, but more importantly, to be able to express that value to others. It does so by providing a means of talking not only about the content of his experience, but also about *how* he experiences it in relation to other experiences. Such a learning is a powerful tool which a manager can in a very real sense use to manage his own learning.

The analysis underlying the method is very simple, and much could be done to extend both its power and applicability so that the method could be made more conversational and the analysis able to deal with structures of concepts. Such a development would make the method more immediately accessible to greater numbers of managers, particularly if implemented cheaply on a desk-top microcomputer. Throughout this paper, the method has been talked about in relation to managers' activities. As a tool for enabling greater effectiveness in the process of strategic management it could perhaps have large impact on the structural ossification of his society. In the long run, however, its importance will be as a practical way both of developing people's sensitivity to the possibility of change, and also of developing their capacity for learning.

References

ARGYRIS, C. & SCHON, D. A. (1974). *Theory in Practice: Increasing Professional Effectiveness.* Jossey-Bass.

BOOT, R. (1979). New methods for management development. The management learning project. *Industrial and Commercial Training*, **11** (1), 8–11.

BOXER, P. J. (1978). Developing the quality of judgement. *Personnel Review Spring*, **7** (2), 36–39.

BOXER, P. J. (1979). Designing simulators for strategic managers. *Journal of Management Studies*, **16** (1), 30–44.

BOXER, P. J. (1980). Supporting reflective learning: towards a reflexive theory of form. *Human Relations*, **33** (1), 1–22.

FIELDEN, J. & PEARSON, P. K. (1978). *The Cost of Learning with Computers.* The Report of the Financial Evaluation of the National Development Programme in Computer Assisted Learning. Council for Educational Technology.

FRANSELLA, F. & BANNISTER, D. (1977). *A Manual for Repertory Grid Technique.* London and New York: Academic Press.

HOPPER, R. (1977). *National Development Programme in Computer Assisted Learning. Final Report of the Director.* Council for Educational Technology.

KAUFMANN, A. (1975). *Introduction to the Theory of Fuzzy Subsets, Volume 1.* London and New York: Academic Press.

KELLY, G. A. (1955). *The Psychology of Personal Constructs.* New York: W. W. Norton.

WALTON, R. D. & MCKERSIE, R. B. (1966). Behavioural dilemmas in mixed-motive decision-making. *Behavioural Science*, **11**, 370–384.

One thing leads to another: a new approach to elicitation in the repertory grid technique

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This paper describes an interactive computer program for the elicitation of a repertory grid. The elicitation approach adopted is unique in that it can *only* be practically undertaken by computer. This represents a move from "classical" techniques (interactive or otherwise), and enables the respondent to be an active rather than passive participant.

The approach is claimed by the authors to be nearer to Kelly's concept of conversation than other interactive techniques.

Introduction

A computer can be used in two ways to assist the researcher who is collecting and analysing repertory grid data. The first is to analyse the matrix of numbers obtained in such a way as to be revealing in terms of the underlying structure of the constructs and their relationships amongst the elements. Sophisticated numerical analytical techniques are required for this aspect and a number of programs have been written to achieve this end (Slater, 1977; Shaw, 1980). Repertory grid usage has increased in latter years largely as a consequence of the increased availability of computers for this kind of analysis. The second way in which computers can be used by the researcher or clinician using repertory grids is to facilitate the elicitation of the grid itself. Shaw & Thomas (1978) and Shaw (1980) describe one such program 'PEGASUS" and Boxer (1979) has developed a similar kind of program.

Shaw & Gaines (1979) noted the value of the absence of interpersonal interaction:

> When constructs are being elicited by a computer program then one is more likely to accept that is precisely and only oneself that is being portrayed.

Bell & Keen (1980) have drawn attention to another advantage. If grids are monitored as they are elicited then statistical information may be used in decision making about such things as the termination of the elicitation procedure.

However, in the above-mentioned procedures, the repertory grid technique is assumed to be fairly standard. Firstly, a set of relevant elements is fed into the computer which returns three of them (a "triad") among which the respondent must group two to form the emergent pole of the first construct and identify the third with the implicit pole of the construct. The procedure is basically repeated with subsequent triads although feedback may be employed with respect to constructs and or elements as in PEGASUS.

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This procedure has a number of advantages although there has been surprisingly little research into actual elicitation procedures. Triadic elicitation tends towards the statement of unidimensional bipolar constructs—although it is arguable whether this necessarily extends to the rating of the elements on this construct—and thus analysis by clustering or principal components may proceed from reliable bases.

The clinician, in eliciting a grid in what may be termed traditional ways may choose from an enormous repertoire of techniques, many of which have been well documented (Fransella & Bannister, 1977). The grid, as Kelly argued (Kelly, 1955) is merely a means of communication by conversation and the techniques referred to above are means to achieve that end. One feature of many such strategies is triadic elicitation and whilst this, as we have shown, exhibits a number of advantages, it does present difficulties when used by clients of low intellectual ability or with young children who find the technique difficult to grasp. Indeed there have been a number of research projects quite appropriately choosing to use grids and later abandoning the methodology due to apparently insurmountable "administrator" difficulties (Abbott, 1979). The terminology is often unavoidable and the notions such as a triad unusual and even perhaps somewhat unnatural as a way of thinking. The argument can even be raised that computer elicitation of this kind does not actually do anything a human administrator could not (leaving aside interpretive aids).

The present approach attempted to avoid these problems. We began by thinking about how people think and converse. Drawing on our own experience, talking with our wives about the works of Conan Doyle, Poe and James Joyce, not to mention Freud, we came to the conclusion that thinking reflectively and conversing is meandering and

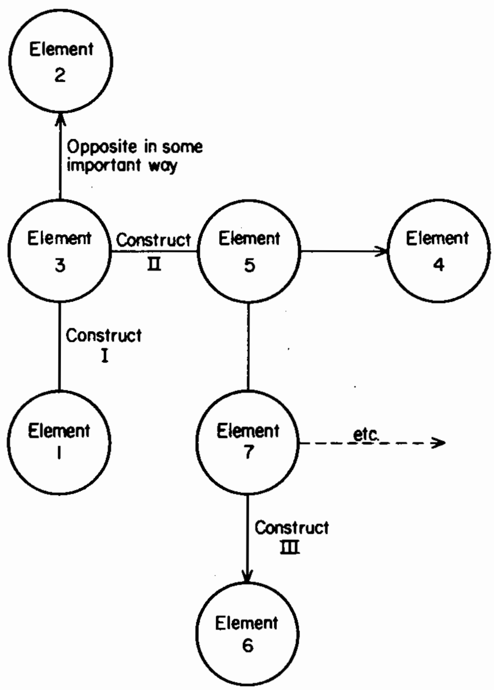

FIG. 1. DYAD elicitation of elements and constructs.

unsystematic. People "string thoughts together" and often "one thing leads to another". Whilst it is difficult for an administrator to systematize such thoughts, into a form suitable for analysis, we reasoned that a small computer ought to be able to cope. In the next section we outline the basic rationale of our approach.

One thing at a time

The basis of DYAD is the consideration of one element at a time. A second element is chosen as being different in some way (this way being the construct) and a third element also chosen as relating to this construct. This third element becomes the first element for the next construct, and so on. The elicitation procedure is shown diagrammatically in Fig. 1.

In this fashion elements and constructs are elicited conjointly. We would argue that it is not possible to consider elements without constructs (witness Zen paradoxes) and that classical elicitation leaves the constructs unstated and the elicitation is a procedure of uncovering these. In the present approach an element cannot be included without an accompanying construct, and likewise the constructs cannot exist without elements. The reason for including the third element (somewhere on the construct) is that we would argue that this element is introduced because it is important to the person, not in the way of the just elicited construct, otherwise it would have been chosen as the second pole, but in a different way, which forms the subsequent construct.

The computer program

A run of an actual inquiry is shown in the appendix.

The program starts with a casual invitation to participate, by asking the client to specify the area of interest. This has a twofold function. Firstly, it enables the client to define for himself the boundaries beyond which he will not proceed. Secondly, it allows the program to converse with the client in his own words. This leads to a request for the first item, which in normal grid parlance is an element, which is followed by a request for the second element, framed in such a way that a construct, not made explicit at this stage ("is different in some important way") determines the choice of element.

The program then requests the client to specify this construct, one pole at a time. The program then calls for another element, which is also in the range of convenience of the construct (to use Kelly's term) but without specifying its location on that dimension.

Next the program asks the client to locate these elements on the dimension by (in the present program) rating. The client then has the option of not adding further elements, otherwise the program continues iteratively adding further elements and implicit constructs.

When the client decides not to add any further elements the process is *not* terminated, for, at this stage, the "classical" grid is incomplete and the pairs of elements added in each cycle will not have been located on the previous construct dimensions. The program therefore asks the client if he would like to undertake this task by completing these ratings. If so, this is done by element (across constructs) rather than, as in the earlier stage of the program (and classical grid techniques) for each construct across the set of elements.

Next the program recaps for the client the elements and constructs elicited and enquires if the client can add any further constructs. If so, the client is asked to enter the poles of the construct, at this stage without reference to any specific elements. The client is then asked to score the elements, one by one, with respect to the new construct. This phase continues until the client is unable to proceed further, or chooses to cease adding constructs. The program currently terminates at this point with a printout (rather than VDU display) of the information provided: area of interest, elements, constructs and scored grid. However, it would be simple to include, at this point, some form of analysis.

PROGRAM EVALUATION

There has been no formal evaluation of the program at this stage but as "grid users" we have identified several differences from conventional elicitation techniques, some of which will be at once apparent from a glance at the appendix. Some of the more significant differences may be considered:

(a) The respondent is, at no time, aware of the fact that he is completing a grid. (In the form of a matrix of numbers.)

(b) Simple, non-technical language forms the basis of the man–machine communication.

(c) "Direction" and "pace" are determined largely by the respondent who may choose to terminate the conversation at any stage, i.e. the client is "active" rather than "passive".

(d) The fact that in this program there is no compulsion in the rating phase for an element to be in the range of convenience of a construct (exemplified by the case, in our example, of the client scoring a zero for one element on a certain construct) lends credence to the view that elements should not be forced into this range either by rating them at the mid-point, often referred to as the point of uncertainty, or for the purposes of convenience in subsequent analysis.

(e) The constructs elicited appear to be somewhat less "logically bipolar" but clearly reflect genuine distinctions. The example in the appendix illustrates one case where the respondent used the same label to "end" two quite distinct constructs.

Conclusions

The authors chose to look again at the administration process and try and identify an alternate approach. Conversations and ideas generated by respondents led incrementally to the idea that the natural way of conducting a "conversation" is incrementalist, i.e. one thing leads to another. Why not therefore start from a single theme and grow (element and construct) from there. This seemed to overcome some of the difficulties of administration and almost accidentally resulted in a dyadic approach which was unique in grid research, namely an elicitation procedure which could *only* be simply undertaken by a computer. We would not deny that there may be apparent weaknesses not the least of which is the difficulty of ensuring bipolarity of constructs elicited in this way, however limited piloting has not shown this to be a major problem (see (e) in previous section). Furthermore, the growing interest in developing Fuzzy set mathematics (Shaw & Gaines, 1979) in relation to grid elicitation could provide a mechanism for permitting degrees of membership of each pole and thus reduce any error which may emerge from this area. One of the authors has, in an associated research project, been considering the possibility of using probability estimates for every element in terms of being a full member of the set identified by each pole. Whilst this work is far from conclusion, due to enormous analytical problems, such a strategy might ultimately further strengthen the DYAD program. These associated developments are only seen as potentially useful if the reflective, simple language approach is further enhanced by their use. The authors contend that any complication of the simple task would weaken the instrument even although statistical analyses might be demonstrably more robust!

In any evaluation of a "new" technique a potential user will weigh the "gains" (over alternative approaches) with the "losses", the authors believe that there are some areas where the "balance" of such considerations is likely to make DYAD almost essential (i.e. previous comment on the elicitation of grids from young children and clients of low intellectual ability) whilst in other areas the "traditional" approach will clearly emerge to be "best". The one feature the authors would want to highlight is the simple way in which the "client" never sees a "grid" and yet is, nevertheless, completing a matrix, sometimes by column and sometimes by row, but always in the cognitive space uniquely defined by the interaction of *both* the element and the construct sample.

A listing of the program, which is written in BASIC for a 56K core Z80 Machine is available from the authors.

References

ABBOTT, J. (1979). Dip. Drama Education dissertation, University of Durham.

BELL, R. & KEEN, T. R. (1980). A statistical aid for the grid administrator. *Int. J. of Man–Machine Studies*, **13**, 143–150.

BOXER, P. (1979). Reflective analysis. *Int. J. of Man–Machine Studies*, **11**, 547–584.

FRANSELLA, F. & BANNISTER, D. (1977). *A Manual for Repertory Grid Technique*. London, New York, San Francisco: Academic Press.

KELLY, G. (1955). *The Psychology of Personal Constructs*. New York: Norton.

SHAW, M. L. G. (1980). *On Becoming a Personal Scientist*. London: Academic Press.

SHAW, M. L. G. & GAINES, B. R. (1979). Externalizing the personal world: Computer aids to epistemology. In *Improving the Human Condition: Quality and Stability in Social Systems*. Kentucky: Society for General Systems Research.

SHAW, M. L. G. & THOMAS, L. F. (1978). Focus on education—an interactive computer system for the development and analysis of repertory grids. *Int. J. Man–Machine Studies*, **10**, 139–173.

SLATER, P. (1977). *The Measurement of Intrapersonal Space by Grid Technique*, Vol. 2, *Dimensions of Intrapersonal Space*. London: Wiley.

Appendix

The following printout is a typical interaction using "DYAD". Words appearing in frames correspond to what the "client" sees on the VDU whilst the final section of the appendix contains the data which is made available to the client in "hard copy" form.

1

```
LET'S LOOK AT THE WAY YOU THINK ABOUT THINGS.

INPUT THE NAME OF THE KIND OF THING (MAN, BOOK DOG, ETC.) YOU
WISH TO CONSIDER.

?BOOK

INPUT THE NAME OF A BOOK THAT YOU WOULD LIKE TO CONSIDER

?BIBLE

INPUT THE NAME OF A BOOK WHICH IS DIFFERENT IN SOME IMPORTANT
WAY FOR YOU.

?THE ASCENT OF MAN.
```

2

```
WHAT IS THIS CHARACTERISTIC AS IT APPLIES TO THE BIBLE

?PHILOSOPHICAL

WHAT IS THE OPPOSING TRAIT OF THE ASCENT OF MAN

?FACTUAL

GIVE ANOTHER BOOK THAT PHILOSOPHICAL/FACTUAL ALSO APPLIES TO

?PLATO'S REPUBLIC
```

3

```
IF YOU WERE RATING THESE THINGS ON A SCALE OF 1 TO 5
(WHERE 1 MEANS MORE LIKE PHILOSOPHICAL, AND 5 MEANS MORE
LIKE FACTUAL)
HOW WOULD YOU RATE THEM?
RATING FOR BIBLE

?1

RATING FOR THE ASCENT OF MAN

?4

RATING FOR PLATO'S REPUBLIC

?2

DO YOU WANT TO ADD ANOTHER BOOK? ANSWER 'YES' OR 'NO'

?YES
```

4

```
INPUT THE NAME OF A BOOK WHICH IS DIFFERENT IN
ANOTHER IMPORTANT WAY FROM PLATO'S REPUBLIC

?ULYSSES

WHAT IS THIS CHARACTERISTIC AS IT APPLIES TO
PLATO'S REPUBLIC

?SEEKING FOR TRUTH

WHAT IS THE OPPOSING TRAIT OF ULYSSES

?DEVELOPMENT OF A NEW LANGUAGE OF COMMUNICATION
```

```
                                                          5

GIVE ANOTHER BOOK THAT SEEKING FOR TRUTH/DEVELOPMENT
OF A NEW LANGUAGE OF COMMUNICATION ALSO APPLIES TO

?KHARMA SUTRA

IF YOU WERE RATING THESE THINGS ON A SCALE OF 1 TO 5
(WHERE 1 MEANS MORE LIKE SEEKING FOR TRUTH, AND 5 MORE
LIKE DEVELOPMENT OF A NEW LANGUAGE OF COMMUNICATION)
HOW WOULD YOU RATE THEM?
RATING FOR BIBLE

?3

RATING FOR THE ASCENT OF MAN

?2
```

```
                                                          6

RATING FOR PLATO'S REPUBLIC

?1

RATING FOR ULYSSES

?5

RATING FOR KHARMA SUTRA

?4

DO YOU WANT TO ADD ANOTHER BOOK? ANSWER 'YES' OR 'NO'

?YES
```

7

```
INPUT THE NAME OF A BOOK WHICH IS DIFFERENT IN ANOTHER
IMPORTANT WAY FROM KHARMA SUTRA

?ENCYCLOPAEDIA OF LOVE

WHAT IS THIS CHARACTERISTIC AS IT APPLIES TO KHARMA SUTRA

?FANTASY

WHAT IS THE OPPOSING TRAIT OF ENCYCLOPAEDIA OF LOVE AND
SEX

?FACTUAL

GIVE ANOTHER BOOK THAT FANTASY/FACTUAL ALSO APPLIES TO

?DR. NO
```

8

```
IF YOU WERE RATING THESE THINGS ON A SCALE OF 1 TO 5
(WHERE 1 MEANS MORE LIKE FANTASY, AND 5 MEANS
MORE LIKE FACTUAL)
HOW WOULD YOU RATE THEM?
RATING FOR BIBLE

?1

RATING FOR THE ASCENT OF MAN

?5

RATING FOR PLATO'S REPUBLIC

?4

RATING FOR ULYSSES
```

```
                                                    9
?1

RATING FOR KHARMA SUTRA

?2

RATING FOR ENCYCLOPAEDIA OF LOVE AND SEX

?5

RATING FOR DR. NO

?2

DO YOU WANT TO ADD ANOTHER BOOK? ANSWER 'YES' OR 'NO'

?NO
```

```
                                                    10

YOU HAVE AN INTERESTING BOOK GROUP. YOU MAY HAVE
REALISED THAT THE LATER ELEMENTS ADDED HAVE NOT BEEN
RATED ON EARLIER TRAITS.
WOULD YOU LIKE TO GO BACK AND 'FILL THESE IN'?
ANSWER 'YES' OR 'NO'

?YES

OKAY, REMEMBER TO RATE AS BEFORE WHERE 1 MEANS MORE LIKE
THE LEFT-HAND TRAIT, AND 5 MEANS MORE LIKE THE
RIGHT-HAND ONE. ENTER ''0'' IF THE TRAIT SEEMS TOTALLY
INAPPROPRIATE FOR THE BOOK.
FOR ULYSSES
RATING FOR PHILOSOPHICAL/FACTUAL

?2

FOR KHARMA SUTRA
RATING FOR PHILOSOPHICAL/FACTUAL

?2
```

```
                                                  11

FOR ENCYCLOPAEDIA OF LOVE AND SEX
RATING FOR PHILOSOPHICAL/FACTUAL

?5

RATING FOR SEEKING FOR TRUTH/
DEVELOPMENT OF A NEW LANGUAGE OF COMMUNICATION

?3

RATING FOR FANTASY/FACTUAL

?5

FOR DR. NO
RATING FOR PHILOSOPHICAL/FACTUAL

?3
```

```
                                                  12

RATING FOR SEEKING FOR TRUTH/
DEVELOPMENT OF A NEW LANGUAGE OF COMMUNICATION

?0

RATING FOR FANTASY/FACTUAL

?1
```

```
                                                    13

YOU HAVE CONSIDERED THESE ELEMENTS -
BIBLE
THE ASCENT OF MAN
PLATO'S REPUBLIC
ULYSSES
KHARMA SUTRA
ENCYCLOPAEDIA OF LOVE AND SEX
DR. NO

IN THESE WAS -
PHILOSOPHICAL/FACTUAL
SEEKING FOR TRUTH/DEVELOPMENT OF A NEW LANGUAGE
OF COMMUNICATION
FANTASY/FACTUAL

CAN YOU THINK OF ANY OTHER WAYS YOU SOMETIMES
DISTINGUISH BETWEEN THEM?
ANSWER 'YES' OR 'NO'

?YES
```

```
                                                    14

OKAY, ENTER ONE END OF THE NEW CONSTRUCT

?PLEASANT TO READ

NOW THE OTHER

?ONLY O.K. FOR REFERENCE

NOW RATE THEM AS BEFORE.  1 MEANS MORE LIKE PLEASANT TO
READ, 5 MEANS MORE LIKE ONLY O.K. FOR REFERENCE.
RATING FOR BIBLE

?2

RATING FOR ASCENT OF MAN

?1
```

```
                                                        15

RATING FOR PLATO'S REPUBLIC

?1

RATING FOR ULYSSES

?2

RATING FOR KHARMA SUTRA

?2

RATING FOR ENCYCLOPAEDIA OF LOVE AND SEX

?5
```

```
                                                        16

RATING FOR DR. NO

?2

CAN YOU THINK OF ANOTHER SOURCE OF DIFFERENCES?
ANSWER 'YES' OR 'NO'

?NO

THANK YOU FOR YOUR INTEREST.  I HOPE YOU ENJOYED
THINKING ABOUT THE WAY YOU THINK ABOUT THINGS
```

YOUR AREA OF INTEREST WAS BOOK IN WHICH
YOU CONSIDERED THE FOLLOWING ELEMENTS -

A. BIBLE
B. THE ASCENT OF MAN
C. PLATO'S REPUBLIC
D. ULYSSES
E. KHARMA SUTRA
F. ENCYCLOPAEDIA OF LOVE AND SEX
G. DR. NO

AND YOU THOUGHT ABOUT THEM IN THESE WAYS -

1. PHILOSOPHICAL/FACTUAL
2. SEEKING FOR TRUTH/DEVELOPMENT OF A NEW LANGUAGE OF COMMUNICATION
3. FANTASY/FACTUAL
4. PLEASANT TO READ/ONLY O.K. FOR REFERENCE

YOU RATED EACH ELEMENT ON EACH CONSTRUCT (WITH 1 MEANING MORE LIKE THE LEFT POLE OF THE CONSTRUCT, AND 5 MORE LIKE THE RIGHT) IN THE FOLLOWING WAY, THE COLUMNS REPRESENT THE ELEMENTS AND THE ROWS THE CONSTRUCTS.

	A	B	C	D	E	F	G
1	1	4	2	2	2	5	3
2	3	2	1	5	4	3	0
3	1	5	4	1	2	5	1
4	2	1	1	2	2	5	2

Education for research: the changing constructs of the postgraduate

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The development of research skills was investigated in case studies of seven Ph.D. students and their supervisors. A combination of repertory grids and interviews was used to monitor changes over time. Focus and Core analyses, together with feedback sessions, helped to isolate specific areas of importance to the postgraduates.

Results indicated that (a) it was necessary for the students to develop an ability to evaluate their own work; (b) the pace of this development appeared to be related to the degree to which the students were allowed to remain dependent on their supervisors; (c) their enthusiasm for their Ph.D. diminished due to the length of time they had to spend working on a single problem.

In addition, it appeared that providing information from the repertory grid to the students helped them to learn from their experiences of the research training process.

Introduction

Very little is known about research at the postgraduate level or what it is that is being assessed when candidates are examined for the Ph.D. degree. The degree is conferred for work judged to make an "original contribution to knowledge" in the students' discipline but it is not clear what this requirement means in practice (Francis, 1976). There are no guidelines for students regarding how it is to be achieved, in fact what is involved in order for a student to produce the completed article is relatively unknown.

Students may eventually discover, at the time of their oral examination, what they have learned during the preceding years in terms of what it is that is needed to bring a research project to a successful conclusion. However, it is the end product which is being judged and upon which the decision concerning success or failure is taken.

Some concern has been voiced by supervisors of research students regarding current training for the Ph.D. degree (Wason, 1974; Baddeley, 1979). These comments, while valuable from the point of view of people who have themselves been involved in the process from both sides, are made without any systematic knowledge of the way in which students experience the training.

In order to acquire some information from the viewpoint of the students, rather than compare differences between successful and unsuccessful candidates, it was decided to pay attention to the process of research rather than to the final product. This is potentially a more illuminating approach, as it leads to an understanding of the requirements for completion of the research degree rather than merely revealing aspects of evaluation of the training based on eventual performance.

The study reported here was part of a larger project which attempted to understand how a small sample of postgraduate students construed their situation as they went through the process of learning to do research.

Specific aspects of the project to be discussed in this paper are those concerned with the students attitudes toward supervision and their relation to their work, together with their perception of actually doing the Ph.D.

As the focal point of the study is the way in which the postgraduates interpret their training, the most appropriate methods for collecting information are those based on the theory of Kelly (1955). Personal Construct Psychology (PCP) arises from his theoretical position that there are no facts in life but only individuals' interpretations of their experiences. The repertory grid is the main psychological technique of PCP and enables the researcher to enter, at least to some extent, the world of the participants. For this reason the repertory grid was used in conjunction with open-ended interviews to study the way in which research students experience the training process for the Ph.D. degree.

Seven research students and their supervisors took part in the study for a period of three years. They came from two universities and a variety of academic disciplines. These were mediaeval history, architecture, English, nuclear physics, biochemistry, astronomy and industrial chemistry.

Although the discipline in which the students were working made a difference to the way in which they were started on their research, it was not a significant variable for any other part of their programme. The science students were part of an organized area of research in which they were presented with a particular piece of work and apparatus. The arts students were left alone to read and think in order to define the area in which they wished to work. The more highly structured introduction of the science students and less highly structured introduction of the arts students, made no difference to the fact that all the postgraduates had to isolate a particular problem, with clear boundaries, as their own specialized topic.

The postgraduates were interviewed every month. In addition, a repertory grid was completed by each student at their first interview and subsequently at 6-monthly intervals. Elements were elicited by asking each student individually to give at least eight items which they considered to be essential for successful completion of the Ph.D. degree from the time of registering for it until they have passed their viva. They were told that these items could be either abstract qualities or activities to be undertaken. In this way the postgraduates were encouraged to think about requirements for the Ph.D. in a more precise and analytic manner than is usual for research students at the start of their course.

The constructs were elicited by triadic sorting of the elements into two which were similar (emergent pole) and one that was different (implicit pole). The reasons given for similarities and differences of each triad of elements constituted the constructs of the grid. These constructs were used to represent a 5-point scale ranging from the emergent pole (1) to the implicit pole (5). All elements were then rated on all constructs. In this way, each student's set of six grids was different. At each 6-monthly grid session throughout the three year period of their research, the students were presented with their own original grid made out of these eight elements and constructs. They were given the opportunity to add more constructs and elements to the grid at each of these sessions. Each time the postgraduates were required to rate all elements on all constructs. Table 1 lists the original eight elements and constructs† of those postgraduates discussed in this paper.

The grids were then analysed using the FOCUS program (Shaw & Thomas, 1978) and CORE program (Shaw, 1979). The FOCUS program prints out individual grids, re-ordered in such a way that relationships between elements and constructs are visible. The core program analyses two grids, comparing each element and each construct with itself and printing out those constructs and elements that have changed the most in the way the postgraduate is using them. These grid analyses were used to form the basis of a feedback session during which the postgraduates could comment on the information presented to them by the researcher.

Depending on which two grids were being discussed, it was possible to give the postgraduates information concerning changes in the way they thought about certain aspects of their work. The feedback session was the forum for discussing possible causes of changes in thinking about their work since they last completed a grid, or since they started the Ph.D., or since the same time a year earlier. In this way the postgraduates were helped to articulate, in some detail, aspects of their thinking about their work that had not previously been clearly defined.

Much of the data on which this paper is based results from postgraduates responses to the question "The way you think about . . . has changed in the last six months, (or since you started your Ph.D., etc.). Can you account for it?" from the researcher. By this means the changes in the students' views of their work, as they occurred during the three years, was monitored while the students explored issues of importance to them. The use of this grid-plus-feedback technique also helped the postgraduates to define their roles as research students.

This type of learning is rare during research degree training and it is clear that the two results of the feedback sessions must interact. Therefore, part of what is being produced in the research results is a direct effect of the methodology used. It is suggested, however, that the information acquired through these means is no less valuable for being the outcome of action research of a novel kind.

The first FOCUSed grid of one of the postgraduates, revealed that his elements "Synthesize theories", "Deal with student", "Meet with supervisor" and "Reading" were all seen in terms of being passive analytical activities which were interdependent with others and helped him to understand others. Similarly, his elements "Thinking", "Making conjectures", "Writing" and "Devising tests" were seen as intellectually active and creative, requiring him to rely on himself and helping him to understand himself.

When these links between elements and construct clusters were made explicit his reaction was one of extreme disappointment. Postgraduate 1 said that he completely recognized himself from the analysis and, therefore, had not learned anything as everything that had been said he had taken for granted for years. Once it was suggested to him that, on the strength of only one meeting, he had been presented with a picture of himself that he knew perfectly well but that the researcher had not known at all before then, he said that he found that "very impressive indeed". On this kind of testimony,

† No grids are reproduced as the comments are derived from the Core analysis which compares pairs of grids, so that for each example of a single changed construct from only one postgraduate, two full FOCUSed grids would need to be given in illustration.

TABLE 1

	Elements	Constructs
Postgraduate 1	Devise Tests	Analytic Activities/Creative Leap
	Synthesize Theories	Interdependant with others/Rely on myself
	Make Conjectures	(Intellectually) Active/Passive
	Meeting with supervisor	Difficult/Easy
	Thinking	Helps me to understand myself/Helps me to understand others
	Deal with students	High degree of fulfillment/Low fulfillment
	Reading	Grow and develop through immediate feedback/Long-term result
	Writing	Most like to do/Least like to do
Postgraduate 2	Obtain results	Needs thought/Tells if on right path
	Carry out measurements	Gather information/Give out information
	Reading	Positive feedback/Own initiative
	Thinking about what you've read	Mere recording/Technique important
	Interpret results	Ability to notice mistakes important/Reproducibility
	Linking literature and measurements	Enjoy/Laborious
	Complete write-up	To do with understanding/Ability to use what is understood
	Good relationship with supervisor	Takes long time/Quick
Postgraduate 3	Think of relevant experiments to test hypothesis	(Thought) Almost same process/Mechanical rather than thought
	Be able to interpret results of experiment	Involves reading/Involves writing
	Survey literature and keep up to date	Reference to literature/None
	Pick out item from literature that needs investigating	Making conclusions/Formulating hypotheses
	Carry out experiments	Validity of experiment assured/Validity of experiment assumed
	Present conclusions verbally	Difficult/Easy
	Present written conclusions	After experiment/Before experiment
	Check experiments	Time consuming/Quick
Postgraduate 4	Reading	To do with time/Can do anytime
	Taking notes	(All to do with people) Directly Ph.D./More indirectly
	Writing	To do with people/Not to do with people
	Attending classes	Almost mechanical process/Not automatic
	Getting on with tutors	(Process) Means/(Result) End
	Keeping other work in bounds	Like/Don't like
	Organizing time	(Self-assessment) Good at/Not good at
	Thinking it out	Creative/Not Creative

TABLE 1 (cont.)

	Elements	Constructs
Postgraduate 5	Reading	Concerns discussion with others/Important for me only
	Writing	Private activities/External discipline
	Thinking	Natural inclinations/Self discipline
	Seeing supervisor	Possibility of terminating/Acceptance of research
	Contacting others in the field	Non-professional life/Professional activity
	Setting and meeting targets	In London/Anywhere
	Avoidance of overwork	Home/College
	Intervention of unprecedented event	Fulfilling/Frustrating

which is not atypical, the analyses plus feedback sessions were taken to give an accurate picture of the way in which postgraduates perceived their situation.

The open ended interviews had already shown that the students' attitudes toward the Ph.D. changed as they came closer to the time for completion (Phillips, 1979) but the grid analyses and feedback sessions gave more detailed information. This was concerned with various aspects of their work, two of the main items being those to do with supervision and the students' relations with their Ph.D. project itself.

The student and supervisor relationship

The regular interviews had shown that the length of time it took for research students to become autonomous research workers was dependent upon the kind of supervision they received, but the grids made it possible to bring out the topic for further discussion with the postgraduate sample. The combination of the analyses of the grids and the feedback sessions revealed an inverse relationship between dependence on the supervisor and involvement with the work for its own sake.

The CORE analysis of his first two grids showed the most changed construct of postgraduate 1 to be Easy/Difficult (44% match). Inspection of the two FOCUSed grids showed the way in which it had changed. In the first grid this construct had been quite separate from the others. In the second grid it had been linked to the constructs Most like to do/Least like to do and Immediate feedback/Long term results. When postgraduate 1 was asked about his reaction to the cluster Easy, Most like, Immediate feedback, he said "The obvious thing is the uncertainty and conviction of failure. I worry about doing the right thing and what others think."

Another cluster revealed by the FOCUS analysis of his second grid was the link at 84% of the elements Thinking and Making conjectures which were seen in terms of the constructs Intellectually active and giving a high degree of fulfillment. Postgraduate 1 responded to this information: "I get fulfillment from the intrinsic nature of the work". Here, after only one year, it was already becoming apparent that satisfaction from the work itself was balanced against the need for explicit information and approval from external sources.

At the end of his final year, when he completed his sixth grid, the CORE analysis showed that the match between the construct Immediate feedback/Long term result on his first and last grids was only 40%. Postgraduate 1 explained this by saying "in the very beginning I wanted immediate feedback and was afraid to ask. When I got it, plus the confidence, I stopped working so hard and felt secure." Here, he is relating growing autonomy with lessening dependence on productivity.

As it is from output that the supervisor is able to evaluate progress in explicit terms for feedback to the student, this comment from postgraduate 1 may be interpreted as independence from external approval coupled with increasing reliance on the information he received as he worked on his topic.

He may be compared with another postgraduate whose most changed construct, Enjoy/Laborious was matched at only $12\frac{1}{2}$% on his first and final grids. He explained this by saying "in the beginning you don't fully understand why you do things. Once you begin to appreciate it more fully, it makes a difference." However, postgraduate 2 did not continue to develop the confidence in his own work that was necessary if he was to be able to rely on the information provided by the results. He was happy to depend on his supervisor but commented on how the particular style of supervision he had received had affected his work.

The CORE analysis of the final grid of postgraduate 2 showed that the construct "Own initiative/Positive feedback" was matched with itself at 14% for the first grid and 57% when compared with the grid he had completed only six months earlier. When asked about this, he replied "I don't think that my early relationship with my supervisor was good and he wouldn't give me information first hand. At first I had to do all the work without any lead, but later on that changed. If you begin to enjoy the relationship with your supervisor then positive feedback is obvious. Some supervisors would opt for the student to dig up the research themselves; it would make you approach the problem differently and is a better training for later work when you have to cope alone."

Almost without realizing it, this postgraduate had linked the amount of dependence on his supervisor with a lack of intrinsic satisfaction from and involvement with his work. He was explicit about the importance of external reinforcement and aware that his own training may not have been the most efficient for later autonomy in research. This suggests that, together with the importance placed on the need for information concerning progress which the student expects to receive from the supervisor, is the equally important need for the student to understand and accept the feedback which is constantly available in his own work.

These results suggest that it is very important indeed for the students to learn to interpret and use the feedback which is contained within their own work and of which they are initially unaware. It may be that the supervisor is important in the early stages of the work to act primarily as mediator between the students and their output. Once students have learned the skills and acquired the confidence necessary to assess their own efforts, their dependence on the supervisor begins to be superseded by their reliance on their own ability to evaluate their progress. The suggestion here is that it is this skill the supervisors are required to teach, by example, to their students.

Changed perception of the Ph.D.

At their original briefing interview, when the postgraduates had first agreed to become part of the research sample, they had all been asked why they had taken the decision to study for a research degree. At that time they had said either that it would allow them to make a personal contribution to their field or that it would enhance the choices open to them for their future career, or both. By the time they had reached their final year, the grids showed that the way in which the postgraduate sample thought about their Ph.D. had changed considerably.

The postgraduates had commenced their 3-year course full of enthusiasm, but once the research had been completed and they had only to write the thesis in order to complete the Ph.D. they spoke of wanting "to get it and forget it". What the grids typically reveal is illustrated in the following example taken from the end of the second year of one of the students.

Discussion of the several constructs that had changed since she had completed her first grid led her to comment "it's a totally different way of thinking because I'm aware that I've got only a year left and two years have already gone. Three years doesn't seem half long enough; it seemed a long time in the beginning." When she was shown that the element "Be able to interpret results of experiments" was grouped quite differently in her latest grid compared with all the preceding ones (FOCUS analysis) postgraduate 3 said "That is because I'm trying to finish off groups of experiments and say 'that's the answer' rather than exploring it more fully, which is what I used to do. Before I was aiming for 'the truth' now I'm aiming for results. I'm looking forward to finishing rather than doing the work for its own interest."

Unfortunately, this disillusionment was the rule rather than the exception with the postgraduates in the sample. Another student had originally seen his work resulting in a creative end product which would emerge out of the mechanical process of collating manuscripts. He was shown that the CORE analysis of his first grid and the one he completed $2\frac{1}{2}$ years later gave only a 56% match on the construct "Almost mechanical process/Not automatic". His response to this was "I'm really fed up with it right now, doing the mechanical things just goes on".

This was from an arts student but another science student, at the same stage in his degree course, reported during the grid feedback session that he had become more remote and detached. He said "in the beginning I had to concentrate hard on what I was doing, it completely occupied my mind. In some ways I've got less enthusiastic, all I want to do is finish and get out." Everything in the comparison of his first and latest grids pointed to the differences in his early and more recent perceptions of doing the Ph.D. He said "at first I was full of enthusiasm for work and work was going to be very important, but at the end other things gave me much more satisfaction. The work was boring and monotonous and I was waiting for it to be over and done."

These remarks from both science and arts postgraduates are similar in their reference to the repetitive nature of the work. The regular interviews had established that there was a growing disillusionment with and disinterest in the programme on which they had embarked so enthusiastically. The reason for this disillusionment and unrest only became clear when the discussion was based on the particular constructs that had changed within a certain period.

One postgraduate who changed to a more positive perception of his Ph.D. over the same period commented when asked about his reaction to the grid feedback sessions, "I might have formulated it differently, but I'm not surprised. It's a useful breakdown of the conceptualization of my gradual acquiescence." Evidence of this gradual acquiescence to complete the research and write the thesis comes from the CORE analysis of the two grids elicited during the first half of his final year. This postgraduate's construct

"Looking forward/Looking back" had changed the most (50% match) which he explained by saying "my concern about the future has acted to keep me going on the thesis. I need to feel I've rounded off a schedule of work in the three years."

At first postgraduate 5 had gravitated into research because he couldn't think what else to do, but had said that he was doing the research "because I want to do it and if I had to force myself to do it then I would stop." Throughout the three years his grids showed up this oscillation between the poles of constructs that he labelled "Natural inclinations/Self-discipline" and "Non-professional life/Professional activity". The differences in the way he thought about these constructs at the start of his research and toward the end were shown up in the CORE analysis of his grids. His comment on this is most specific; "These two concepts have often fought for mastery over me. I think the discipline has gradually gained the upper hand. In the three years the natural inclinations to do anything other than finish the thesis have become less pressing so the concepts are less radically opposed now than they have been in the past."

Postgraduate 5 had started his research degree with an idea that he may not complete it. This had gradually changed so that finally the thesis had become one of the most important things in his life. He gave "I've surrendered to my fate" as a superordinate construct when asked if there was any way in which he could describe why these things were important to him. He added "at first there was a lot of chafing and inner rebellion and I was dissatisfied with the department and supervision but, although I don't admire the way things are handled . . . I don't contact first year postgraduates because I wouldn't want to be part of helping them not to experience anything that they need in order to become more self-reliant". This is not only a reversal of the way in which he had originally seen things, but also a direct comment on the relationship between lack of direction from outside and development of autonomy.

This student had been left alone for long periods from early in his research except for occasional meetings with his supervisor, which he initiated when he wanted to discuss the plan of his work. Because of the lack of postgraduate seminars and contact with others in his department, this student had experienced postgraduate life as one of almost complete isolation. His supervisor's role had been mainly to help him to structure his work, including the use of short term goals, and eventually to comment on the result. This strategy helped postgraduate 5 to become more confident of his ability to plan, carry out and evaluate a research project on his own.

Conclusions

This study of a small number of postgraduates who registered for research degrees in 1976, has shown how certain aspects of the training process was experienced by them. With the use of grid methodology, based on Personal Construct Psychology and analytic techniques that facilitate comparisons between grids of one individual elicited at different times during the 3-year programme, information has been systematically acquired concerning the kinds of changes that occur. Using the grid analyses as a basis for open ended interviews it has also been possible to note when these changes occur and why they occurred when they did.

The main points discussed in this paper have been concerned with the postgraduates' changing constructs relevant to the importance of supervision and their conception of the supervisory role, together with the significance of the Ph.D. degree to them. Although these issues had been partially explored in the regular interviews, it was only in the feedback sessions that the more subtle details were uncovered as a result of discussion regarding which elements and constructs had changed in a given period.

The interview data had already revealed that supervisory style directly affected the way in which the postgraduates approached their work (Phillips, 1979). The important additional information revealed by the grids was the connection between this and the postgraduates' appreciation that their own actions could be used to monitor their performance. Once they were able to make use of the information concerning their progress that was contained within their own work, they began to reflect on their own performance and evaluate it.

It is at this point that the students' perception of the supervisors' role changes. Instead of seeing it as one of primarily generating external approval and information, the supervisor becomes somebody with whom they can discuss new ideas and develop earlier thinking. The supervisor is used as a sounding board, as an expert with the ability to proffer the reverse arguments to be countered. The supervisory role is changed from one of tutor to that of colleague through the developing autonomy of the postgraduate.

This comes about as a result of the students' increased ability to evaluate their own work. The teaching of this skill, together with those needed to impose structure on the planning of projects, was what the postgraduates in the sample most needed at the start of their 3-year training in research. The changing constructs of the postgraduate involve an expectation of less direction from their supervisors and more guidance through the negotiation of suggestions originating from either the student or the supervisor.

The postgraduates' changed perception of the Ph.D. degree was also apparent from the interviews but it was only the grid analyses which resulted in the knowledge that it was mainly due to repetitive work and the monotony of concentrating on the same thing for an extended period of time. Also, the possibility of a link between supervisory style, developing involvement with work and increasing enjoyment of research is indicated by the equally definite, but encouragingly different, change in perception of the Ph.D. of one member of the sample.

There are indications from the comments of the students that the continuing use of the grid throughout their period of research helped them to isolate precise problem areas. This knowledge was often used by them either to decide upon a course of action or to define and understand the source of irritants which they had previously been unable to locate.

It is clear from these results that valuable insights can be acquired by both parties when series of grids are used as a tool to help understand changing attitudes and ideas from the point of view of the participants. This use of the grid technique permits straightforward negotiation of constructs that change over time between those being researched and the researcher. It may well be that it could be incorporated into the postgraduate educational plan as an instrument to help students and supervisors identify problems and develop strategies for a more humane training in the skills needed for successful research workers.

This research was carried out for a Ph.D. at the University of London under the supervision of P. C. Wason.

References

BADDELEY, A. (1979). Is the British Ph.D. system obsolete? *Bulletin of the British Psychological Society*, **32**, 129–131.

FRANCIS, J. R. D. (1976). Supervision and examination of higher degree students 2. *Bulletin of the University of London*, **31**, 3–6.

KELLY, G. A. (1955). *The Psychology of Personal Constructs*. New York: W. W. Norton.

PHILLIPS, E. M. (1979). The Ph.D.: Learning to do research. *Bulletin of the British Psychological Society*, **32**, 413–414.

SHAW, M. L. G. (1979). Conversational heuristics for eliciting shared understanding. *Int. J. Man–Machine Studies*, **11**, 621–634.

SHAW, M. L. G. & THOMAS, L. F. (1978). FOCUS on education: an interactive computer system for the development and analysis of repertory grids. *Int. J. Man–Machine Studies*, **10**, 139–173.

WASON, P. C. (1974) Notes on the supervision of Ph.D.'s. *Bulletin of the British Psychological Society*, **27**, 25–29.

Personal construct psychology in education and learning

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Recently educational technology has undergone a change of emphasis in the methods and means of teaching: from mass instruction through individualized instruction to group learning. This re-orientation parallels developments within education itself of the three stages of dependent, independent and interdependent learning. This paper discusses the contribution which can be made to this development by personal construct psychology, and in particular the practical role in it of the PEGASUS and SOCIO-GRIDS programs for construct elicitation and analysis.

Introduction

In recent years there has been increasing discontentment with the models of learning upon which education and training are based. Much of the emphasis in this paper is on education in schools and colleges, but it is suggested that the issues raised are equally relevant to education and training in the wider sense, at work and at play. Hayes (1978) suggests a closer alignment of education, training and work, and indicates that "learning-to-learn" is as important a concept for industry and commerce as it is becoming within schools and colleges. There is growing recognition within industry of the need for establishing the personal strategies used and the values held by the learner in relation to any particular learning task. New techniques are evolving which encourage the individual learner to confront these aspects and to take an active and responsible part in the learning process. Each of us has an implicit model of the learning process which will have an impact on our behaviour as learner or teacher/trainer.

The theories underlying the practice of educational research are also intimately linked to general educational ideologies. These educational ideologies embody theories of the nature and development of man. As Bruner (1966) pointed out—instruction can be seen as an effort to assist or to shape growth and that any theory of instruction is in effect a theory of how growth and development are encouraged. Any theory about teaching is thus inextricably linked to an underlying view or model of the nature of the learner. A teacher/trainer may conceive of the nature of the learner as active or passive, or meaning seeking, or impulse driven, fixed or constantly developing. Whichever model is adopted will influence that teacher's teaching strategy and objectives.

Much of the current debate on education revolves round fundamental differences in the models of learning held by the individuals concerned. Many educationalists argue that a major problem is that at any point in time educational issues tend to be dominated by one particular viewpoint or "frame of reference" so that education becomes monolithic in structure (Joyce, 1972). Those involved in education often adopt rigidly opposing positions which mitigate against a more constructive and flexible approach. There is now a growing recognition that alternative models can co-exist and enrich rather than detract from development in education. Some educational researchers are seeking new approaches—recognizing that past educational research has been conducted on too narrow a base. Snow (1974) discusses these issues in relation to research on teaching and suggests that we should be concerned with (Snow, 1974, pp. 288–289):

> Adapting methodology to match the complexity of students and situations in schools.... Hopefully in future programmes of research, alternative kinds of designs will be used and various hybrids will be invented so that the advantages and disadvantages of each can be counter-balanced and more clearly understood.

Repertory grid techniques evolving from the work of George Kelly (1955) are proposed as one possible alternative mode of inquiry within educational research. This is an alternative methodology which will allow both the researcher/teacher and participant subject/learner a means of monitoring and reflecting on the idiosyncratic frames of reference which the learner evolves. Rather than the imposition of a monolithic approach to educational issues, a Kellian framework allows for diversity of viewpoints and constructive alternatives in education. This paper will discuss the development of resource tools which have their roots within Personal Construct Psychology and which are now being applied within a variety of learning contexts. Educational Technology in the past has concerned itself with dependent learning situations. Recently emphasis has been placed upon independent and interdependent learning (Elton, 1977) and the PEGASUS and SOCIOGRIDS programs derived from repertory grid techniques (Shaw, 1980) have been applied to these areas. These are also applicable in the areas of computer assisted learning, self-organized learning in education and industry, study counselling or management development.

An ideological context

Traditionally the educator's job was seen to be the direct instruction of information and rules, and education was seen as the transmission of the culturally given. For example, Robert Maynard Hutchins (1936, p. 66) wrote:

> Education implies teaching. Teaching implies knowledge. Knowledge is truth. The truth is everywhere the same. Hence, education should be everywhere the same.

Much of the basis of Educational Technology and behavioural modification approaches to education can be seen as variants of this cultural transmission approach. Knowledge and values are seen as located in the culture and are internalized by children imitating adult behaviour models or through explicit instruction and the use of such training procedures as reward and punishment. The criterion of successful education for such theorists is the student's ability to incorporate the responses he has been taught and to respond to the demand of the system.

Skinner (1968) views teachers as architects and builders of student behaviour. He defines learning as a change in the probability of response. He seeks to explain all human behaviour in terms of respondents and operant reinforcement. Through progressively changing the contingencies of reinforcement in the direction of the desired behaviour (as defined by the teacher) learning is seen to occur. Educational change is evaluated from *performances*, not from *changes in thoughts or feelings*. Traditional teaching methods are often referred to as "expository presentation" or "receptive" learning methods which emphasize the student's role as the passive receiver of information rather than the active participant. The dominant idea was that students do not have sufficient self-direction to work out educational programmes in collaboration with their teachers thus the students had little or no control over the manner in which they are taught and curriculum content.

This view of teaching and learning has dominated western education and has been supported by psychological theories of development which stress the passivity of man's mind—associationism, behaviourism, stimulus–response psychology, contingency theories, etc. However, in the last few years we have seen a paradigm shift within psychology and education resulting in a renewed interest in the individual's *active* processing. Knowledge is seen as being produced by transaction between man and his environment and an emphasis is now placed upon an active man reaching out to make sense of his universe by engaging in the reconstruction and interpretation of his own experiences. Following in the traditions of Rousseau and Dewey, modern educationalists maintain that learning should be directly related to the interests of the person; motivation to learn should come from within the person rather than knowledge be imposed upon him. The teacher is seen more as a guide or adviser in a process whereby the person reconstructs the subject matter in accordance with its perceived relevance to his own life.

The teaching methods upheld by Progressivism encourages student–student interaction as well as student–teacher interaction. The teacher is interested in students developing their own criteria regarding the quality and relevance of ideas and he allows this to develop by minimizing his role as an arbiter of what is acceptable. His aim is not the transmission of "nuggets of truth" rather he aims to facilitate the process of learning and the acquisition of personal potency (Brown, 1971).

Many educationalists are now concerned with the active involvement of the learner. For example (Postman & Weingartner, 1971, p. 59):

> There is no way to help the learner to be disciplined, active and thoroughly engaged unless he perceives a problem to be a problem, or whatever is to be learned to be worth learning, and unless he plays an active role in determining the process of solution. . . . It is sterile and ridiculous to attempt to release the enquiry power of students by initiating studies that hold no interest for them.

Kelly recognized learning as a personal exploration and saw the teacher's role as helping

> to design and implement each child's own undertakings. . . . To become a fully accredited participant in the experimental enterprise she must gain some sense of what is being seen through the child's eyes. (Kelly, 1970*b*, p. 262.)

What is relevant to the person is of importance and for education to be a joint venture between teacher and learner it is essential that each has some awareness of the other's personal constructs. The perspective of the student as well as that of the teacher must be considered although traditionally learning has been defined mainly from the latter's perspective.

Perspective of the personal

Many writers on educational issues, e.g. Blumer (1966), Hargreaves (1972) and Morris (1972), have argued that it is time that recognition be given to the perspectives of the people engaged in classroom interaction. Blumer (1966) writing on educational research, suggests that (p. 542):

> Since action is forged by the actor out of what he perceives, interprets and judges, one would have to . . . take the role of the actor and see his world from his standpoint.

This "perspective of the personal" is central to the work of George Kelly. It is implicit in the title of his theory—Personal Construct Theory—and explicit in his writings, e.g. (Kelly, 1970*a*, p. 9):

> We start with a person. Organisms, lower animals, and societies can wait.

The fundamental postulate of Personal Construct Theory, now more popularly called Personal Construct Psychology (P.C.P.), is that "a person's processes are psychologically channelised by the ways in which he anticipates events". For Kelly, man's behaviour is not driven by instincts (as in psychoanalytic theory) nor is it determined by the schedules of reinforcement and associations between stimulus and response (as in Skinnerian and Behaviourist theories). There have been many analogies used in psychology: man—the telephone exchange, man—the hydraulic system, and recently man—the computer. Kelly's analogy was man the scientist. Man the scientist and scientist the man are both engaged in a process of observation, interpretation, prediction and control. According to Kelly, each person erects for himself a representational model of the world which enables him to chart a course of behaviour in relation to it. This model is subject to change over time since constructions of reality are constantly tested out and modified to allow better predictions in the future. Thus for Kelly the questioning and exploring, revising and replacing in the light of predictive failure which is symptomatic of scientific theorizing, is precisely what a person does in his attempts to anticipate events. The person can be seen as a scientist constantly experimenting with his definition of his existence. For Kelly man is himself "a form of motion"—thus he denies the necessity of "carrot and stick" or "impulse driven" theories of motivation. Man is constantly attempting to make sense of his environment and man's anticipation of future events is "both the push and pull of the psychology of Personal Constructs" (Kelly, 1955, p. 49). Kelly does not deny the importance of early experiences or present environmental circumstances but he suggested that it was more important to know what and how a person thinks about his present situation than to know what his early childhood experiences were or in what environmental circumstances he now finds himself.

The "Progressive" movement in education emphasizes the activity of the person struggling to impose meaning on his experiences and rejects the notion of a passive receiver of knowledge. The following quotation from Berman & Roderick (1973, p. 3) indicates some assumptions re curriculum which appear to us to be compatible with Kelly's viewpoint.

> Curriculum has long been thought of as that which is taught to somebody else. . . . The view of these writers is that curriculum must put the person at the centre of what is learned.
>
> Curriculum development and subsequent research on the curriculum will then see the person as the meaning maker and plan curricula experiences which enable the child to

> consider, contemplate, and expand his meanings. Critical to curriculum development, then, is the ascertaining of what is happening to the individual child as he interacts with persons, materials, time and space within the context of the school and the classroom.

This emphasis on the person as the meaning-maker is central to Kelly's position. In order to understand a person's behaviour it is necessary to know how he construes his particular situation. Kelly argues that persons differ from each other in their construction of events (individuality corollary). Lambert *et al.* (1973) discussed the limits of structural analysis of the education system which has become prevalent in recent years. A major assumption of this approach is that structural variables of a school are directly related to aspects of its pupils' society. Kelly would not presume that members undergoing a similar education system or belonging to particular groups would necessarily share the same system of construing. However he did admit the possibility of shared areas of personal meaning and this was made explicit in his commonality corollary (Kelly, 1970*a*, p. 20):

> To the extent that one person employs a construction of experience which is similar to that employed by another, his processes are psychologically similar to those of the other person.

However, it is Kelly's stress on the personal nature of meaning and the elevation of the person to the central focus of inquiry that aligns him with much of contemporary theorizing on education.

A technology

Kelly (1969, p. 135) maintained that

> humanistic psychology needs a technology through which to express its humane intentions. Humanity needs to be implemented not merely characterised and eulogised.

Humanistic psychologists and educators must develop technologies appropriate to their orientation, i.e. tools which help in the articulation of personal perspectives. We would suggest that the computer programs PEGASUS and SOCIOGRIDS are tools which meet this purpose. One of the main advantages of the PEGASUS program for the interactive elicitation of a repertory grid with on-going feedback to the user of highly matched elements and constructs (Shaw, 1980), is that it is content-free. School children, university students, housewives, lecturers and managers have all used the program to construe a variety of elements related to a wide variety of purposes. Examples of these have been significant learning events, audio-visual equipment, architectural styles, examination scripts, prospective careers, mathematical concepts and books.

Figure 1 shows a FOCUSed grid (from Shaw, 1980) which was given at the end of a PEGASUS run. Arthur, who produced this grid, defined his purpose for using PEGASUS as "exploring learning situations". When a high match was found between the elements "tutorial" and "seminar" feedback was given to him, and he was invited to add a construct to distinguish between them. He added the construct "small group–large group" and subsequently rated all the elements on this new construct. At a later stage when a high match between the two constructs "flexible–rigid" and "variable content–specific content" was found by the computer, this was pointed out and Arthur was asked to add an element which was "either flexible and specific content or variable

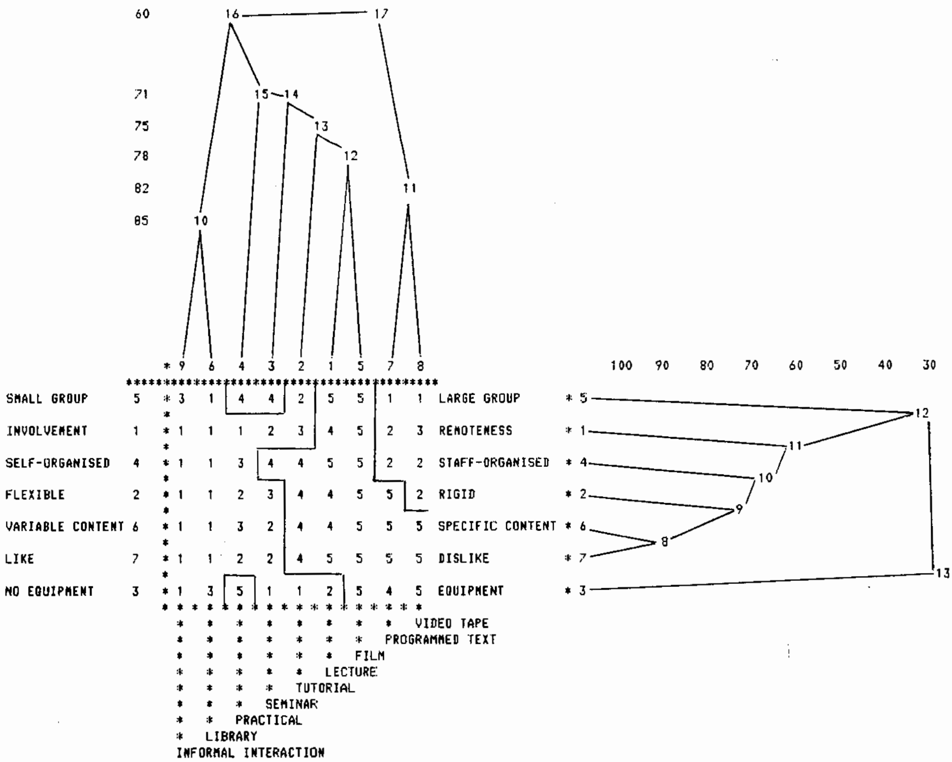

FIG. 1. Arthur's FOCUSed grid from PEGASUS.

content and rigid". He decided to add the element "video tape" which he said was "flexible" and "specific content". Very little structure is imposed on the user and a variety of choice is given wherever possible, thus allowing the learner to choose the level and direction of reflection on his ideas.

It is of course necessary for the learner to relate his construction of personally relevant meaning to bodies of established knowledge and traditional educational disciplines. PEGASUS-BANK is a development of PEGASUS which allows the user to complete a grid on a topic area and get ongoing feedback on the relationships between his constructs and those of "an expert" or the consensually validated definitions which represent public knowledge in the area. We have found that if a tutor and student complete grids on the same topic area this provides a basis for discussion. Externalizing areas of similarity and dissimilarity between a tutor's grid and that of the student gives a framework for negotiation of differences between tutor's and student's perspectives. This leads to a greater awareness and understanding of the other's point of view. If the technique of grid-elicitation together with grid-feedback is used in a "learning-centred" way personal models can be brought into awareness, revised and refined, or even rebuilt to enable learning to be more successful in those areas where inadequate modelling was hindering the learning process.

The SOCIOGRIDS program is used in order to explore the similarity and differences in construing between members of a group. This technique is based on an assumption rooted in Kelly's commonality corollary that there may be areas of shared meaning among any group of individuals. Starting with the negotiation of a common set of elements by the group concerned, this program analyses the set of repertory grids elicited from the group. Each person is free to use his/her own personal constructs. Similarity between constructs is not based upon literal similarity but upon an operational definition of similarity in terms of the ordering of the element set.

Using the SOCIOGRIDS technique each individual in the group has feedback on his own mapping of the area from a FOCUSed grid (as in Fig. 1). In addition the "mode" grid of the most commonly used constructs by all the members of the group is extracted and focused, exhibiting the content of the shared construing in the group. Figure 2 illustrates this mode grid from a group of three staff and four students on education courses in a polytechnic (from Kevill & Shaw, 1980). This was the subgroup having common elements of an initial group of 20 staff and students who had elicited grids to investigate views of the methods of communication used on their courses in the polytechnic.

It appears that there are a number of constructs with the underlying idea of personal contact and participation by the individual, e.g. constructs 9, 3, 6, 7. For some people slightly different meanings are attributed to almost identical words, e.g. constructs 3 and

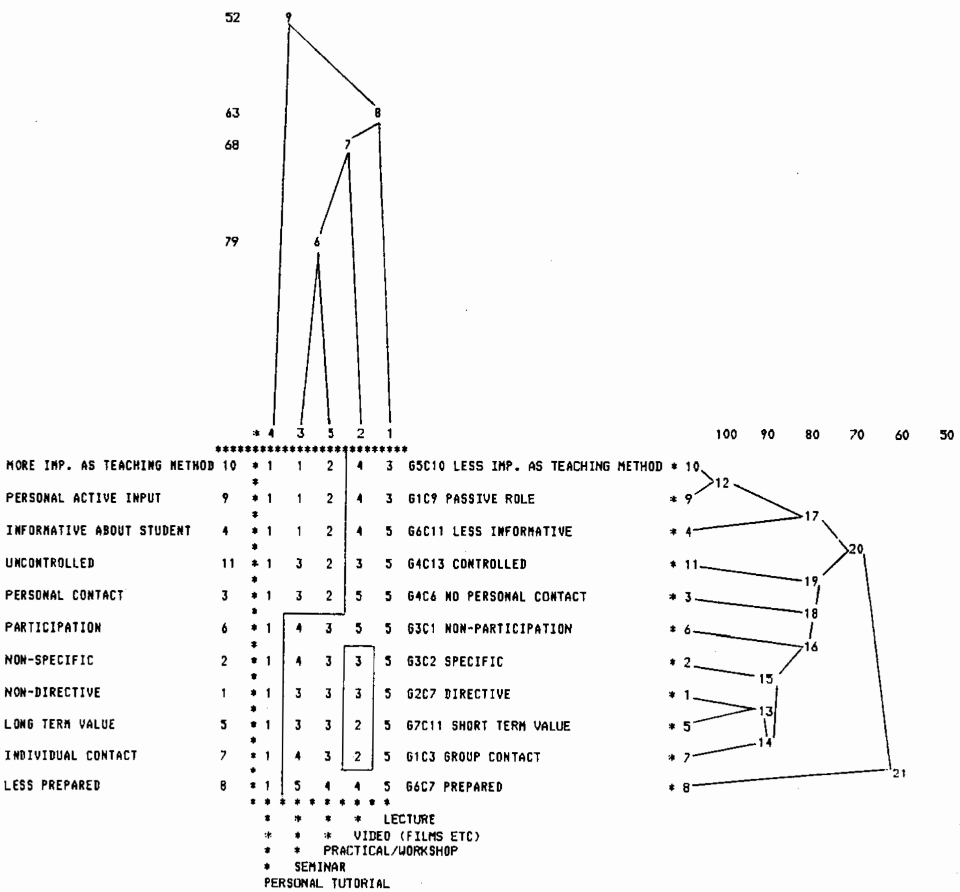

FIG. 2. The FOCUSed mode grid.

7, whilst for others different words are used to express the same ordering of elements, e.g. constructs 9 and 10.

The program also produces a sequence of "socionets" from the matrix of similarity measures between pairs of individual grids. The highest related pair in a group can be extracted as a sub-group where the most commonality of construing occurs and subsequent individuals can be defined by their position in the rank ordering of the similarity measures. Thus, this set of socionets exposes those members of the group who have most in common and those with strongly individualistic viewpoints.

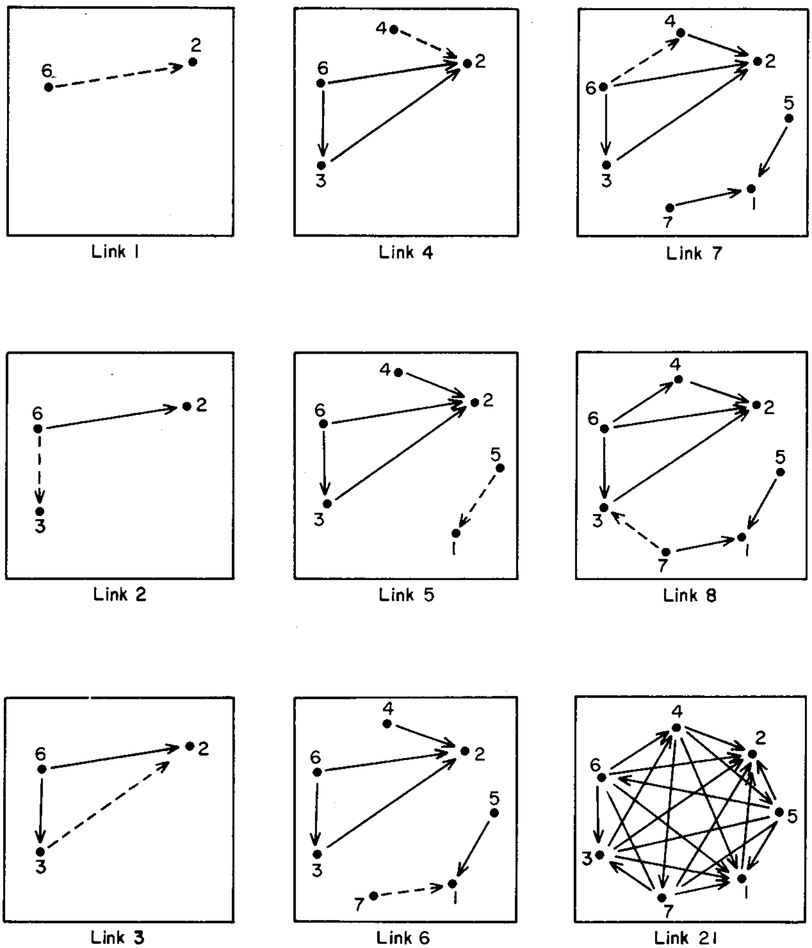

FIG. 3. Part of the sequence of socionets from SOCIOGRIDS.

Figure 3 shows part of the sequence of socionet diagrams from the same group of staff and students. It is interesting to note that all seven members are involved by link 6 showing a high degree of commonality, although at this stage there are two separate subgroups. In the final diagram (link 21) it is interesting to see the direction of the arrows, indicating a wider construct system on the left. Subjects 5, 6 and 7 have all but one arrow leading *from* them indicating an understanding of the others, whilst subjects 1 and 2 have all the arrows pointing *towards* them, indicating a narrower view. Subjects 5, 6 and 7 are members of staff, and subjects 1 and 2 are students.

Conclusion

The SOCIOGRIDS method represents a technological advance which allows the learner to reflect on his personal model whilst offering each member of the group the facility to become aware of the inter-relationships between ideas within the group. It has been our experience that learners become very involved in the process of reviewing similarities and negotiating the differences within the group and find it a relevant learning experience. In some cases it has been the first time the person has dwelt upon the notion of relativity in constructions of reality.

Esland (1971) suggested that, in education, knowledge itself must be dereified. The SOCIOGRIDS program certainly helps this process of dereification. Esland noted that, once dereified, knowledge then becomes (p. 96):

> a much more negotiable commodity between teacher and pupil. Its social-historic relativity is likely to be transparent and the content of knowledge may become subservient to the development of a cognitive technology which is capable of projecting multiple inferential structures containing both enactive and theoretical knowledge.

He suggested that new configurations of knowledge arise from questioning in learning situations and that boundaries between "subjects" are "only human constructs and can, therefore, be broken".

For Kelly the construction of reality is an active, creative, rational, emotional and pragmatic affair. Man the scientist evolves a set of constructions which he tests out and may ultimately discard in favour of a new set of constructions if the former fails to anticipate events adequately. Kelly pointed out that all theories are man-made hypotheses which may fit all the known facts at any particular time but may eventually be found wanting in some unforeseeable respect and eventually replaced by a "better theory". An example from physics is the re-appraisal of Newton's theory by Einstein. However Einstein's theory is not the ultimate truth—Einstein himself regarded his theory as defective and spent much of his life trying to find a better one. In putting forward his theory, Kelly suggested that as a theory it would be subject to revision since it is itself an example of a human construct and so can be seen as an hypothesis waiting to be put to the test.

This view of theory, science and knowledge is echoed in the writings of Karl Popper (1963). He sees science and knowledge as progressing through a series of "conjectures and refutations". Kuhn (1970) analyses the progress of science and suggests that growth of knowledge occurs when the dominant paradigm of the day is challenged by the revolutionaries who step outside the limits of present theory and engage in what Kuhn calls "extraordinary science". Kuhn suggests that professional scientists are educated in the "normal" scientific mode which involves solving problems within the limits of the theory the scientist has been taught. The theory itself is not questioned. If problems are not solved the theory is not invalidated, the scientist lacks ingenuity! PEGASUS and SOCIOGRIDS offer teachers and learners a resource which encourages the individual to reflect on his conceptualizations of his world and an opportunity to explore differing conceptions. Active involvement with his own and others' ideas may encourage the learner to see himself as a more potent force in the determination of his own learning and in the development of new knowledge.

We are grateful to Terry Keen and Nan Kevill for discussions and the use of data.

References

BERMAN, L. M. & RODERICK, J. A. (1973). The relationship between curriculum development and research methodology. *Journal of Research & Development in Education* **6**, (3) 3–13.

BLUMER, H. (1966). Sociological implications of the thought of George Herbert Mead. *American Journal of Sociology*, **71**, 535–548.

BROWN, G. T. (1971). *Human Teaching for Human Learning.* New York: Viking Press.

BRUNER, J. S. (1966). *Towards a Theory of Instruction.* New York: Norton.

ELTON, L. R. B. (1977). Educational Technology today and tomorrow. In *Aspects of Educational Technology* (GILBERT, J. K. and HILLS, P. J., Eds). London: Kogan Page.

ESLAND, G. M. (1971). Teaching and learning as the organisation of knowledge. In *Knowledge and Control* (YOUNG, M. F. D., Ed.). London: Collier–Macmillan.

HARGREAVES, D. H. (1972). *Interpersonal Relations and Education.* London: Routledge and Kegan Paul.

HAYES, C. (1978). Groundwork for a flexible future. *Personnel Management*, pp. 27–29 (March).

HUTCHINS, R. M. (1936). *The Higher Learning in America.* Newhaven, Conn.: Yale University Press.

JOYCE, B. (1972). Curriculum and humanistic education. In *Humanistic Foundations of Education* (WEINBERG, C., Ed.). Englewood Cliffs, New Jersey: Prentice–Hall.

KELLY, G. A. (1955). *The Psychology of Personal Constructs* Vols 1 and 2. New York: Norton.

KELLY, G. A. (1969). The strategy of psychological research. In *Clinical Psychology and Personality: the collected papers of George Kelly* (MAHER, B., Ed.). New York: Wiley.

KELLY, G. A. (1970*a*). A brief introduction to personal construct theory. In *Perspectives in Personal Construct Theory* (BANNISTER, D., Ed.). London: Academic Press.

KELLY, G. A. (1970*b*). Behaviour as an experiment. In *Perspectives in Personal Construct Theory* (BANNISTER, D., Ed.). London: Academic Press.

KEVILL, F. M. & SHAW, M. L. G. (1980). A repertory grid study of staff–student interactions. *Psychology Teaching*, **8**, 29–36.

KUHN, T. S. (1970). Logic of discovery or psychology of research. In *Criticism and the Growth of Knowledge* (LAKETOS, I. & MUSGRAVE, I., Eds). Cambridge University Press.

LAMBERT, R., BULLOCK, R. & SPENCER, M. (1973). The informal social system. In *Knowledge, Education and Cultural Change* (BROWN, R., Ed.). London: Tavistock.

MORRIS, B. (1972). *Objectives and Perspectives in Education: Studies in Educational Theory 1955–70.* London: Routledge and Kegan Paul.

POPPER, K. (1963). *Conjectures and Refutations: the Growth of Scientific Knowledge.* London: Routledge & Kegan Paul.

POSTMAN, N. & WEINGARTNER, L. (1971). *Teaching as a Subversive Activity.* Harmondsworth: Penguin.

SHAW, M. L. G. (1980). *On Becoming a Personal Scientist.* London: Academic Press.

SKINNER, B. F. (1968). *The Technology of Teaching.* New York: Appleton–Century–Crofts.

SNOW, R. E. (1974). Representative and quasi-representative designs for research on teaching. *Review of Education Research* **44**, 265–291.

Construct systems in conflict

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The Social Science Research Council supported a research into a technique for measuring differences of opinion in a dispute from May 1976 to December 1977. It was found that in many cases where informants differed in their opinions about a particular topic grids aligned by element or construct or both could not be devised for comparing them. Each protagonist made use of his own set of terms and had no use for the other's. The methods described by Slater (1977) could not be applied.

A substantial modification of grid technique was devised to bring the views of both sides into a single frame where they can be compared. It is called the Dual Grid. Instead of using constructs and elements as its functions it uses complete propositions. Experimental work with dual grids has not yet been carried very far. One instance is given.

Psychiatric clinics were considered particularly suitable places for studying differences of opinion, because of the many ways in which such phenomena are presented there and the amount of expert attention that can be given to them. The participants in the disputes are usually willing to express their opinions and resolve their differences. So cooperation can be obtained from everyone concerned.

As the research progressed the importance of developing special methods of interviewing became more and more evident. At first the usual methods for obtaining grids were expected to be sufficient, and special methods would be needed for analysing the data obtained from them. The theory proposed was that a common set of elements would be acceptable to both parties for defining the topic in dispute; and the differences between them would be revealed as differences in their ways of construing these elements.

The distance between two elements would appear larger to one of the parties than the other if a construct which distinguished between those two elements seemed important to the one and negligible to the other. The relative contribution of each construct to the distance between any pair of elements is mathematically measurable in every grid; and hence comparisons can be made between any two grids using the same elements. An appropriate method of analysis was actually worked out, but its uses were found to be limited.

The theory turned out to oversimplify the problem. When the parties in a dispute are allowed to express their opinions freely they seldom use the same terms; more often they appear to be using totally different languages. The discussion between them seems not so much like a dialogue as two monologues at cross purposes, intersecting in occasional coincidences.

Even when there is no open dispute between the two parties evidence that they agree is very inconclusive if they apply different terms to the topic under consideration. Psychiatric clinics frequently provide examples of such unintentional misunderstandings. A study was made of the grids of psychotherapists and their patients. Five psychotherapists were included with one patient each. The patient's disorder was the topic in each case. At the beginning of the experiment, the patient was left free to choose his own constructs and elements and so was the psychotherapist. No clear correspondence between the psychotherapist's grid and the patient's was found in any of the cases. Speculating on the causes of his patient's complaint the therapist interprets them in the arcane vocabulary of his profession, into which the patient is not initiated.

After a short course of therapy (between six months and a year) the same procedure was followed. Both patient and therapist were left free to choose the terms for their own grids as before. Remarkably few changes were found. Generally, the patient used the same terms after treatment as before. Some new terms were added, but they were not ones borrowed from either of the therapist's grids. Similarly changes in the therapist's grids to accommodate terms used by the patient were remarkably few. No clear evidence was obtained to support the opinion that patients adopt their therapists' construct systems. On the contrary, their original constructs show marked perseveration, and even when therapy lasted a full year, very few of the therapists' constructs can be seen to have migrated into the patients' construct systems. Likewise there is little indication of the therapists adopting their patients' constructs, and the elements they took over were limited to a few, such as boy-friends, about whom they learned during the course of treatment. Finally, when the changes in the grids were compared with the outcome of the treatment no evidence of any connection was found.

The positive conclusions from this experiment are not impressive, but one conclusion of a negative kind seems unavoidable: the parties in a dispute are likely to persevere in using different, incompatible terms unless the interviewer can persuade them both to adopt compatible ones. The first task was to find suitable methods of interviewing; suitable methods of analysis could be left for consideration afterwards.

An interviewer who relies on personal construct theory will want to intervene as inconspicuously and impartially as possible. The method found generally most suitable was to elicit all the terms for a grid from each of the parties separately. After completing a grid with their own terms each party was supplied with the other party's terms and asked to fill in a grid with them. Thus two pairs of completely aligned grids would be obtained; each grid with terms elicited from one party being aligned to the grid with the same terms supplied to the other.

Various short-cuts were found possible in particular experiments; and this method for obtaining comparable grids from opposing parties was not formulated as a general rule even when it was implicitly recognised. Yet most of the experiments conducted for the S.S.R.C. research adhered to this form in one way or another.

One experiment concerned the opinions of a psychiatrist and a psychotherapist about patients' suitability for psychotherapy. The psychiatrist was accustomed to refer patients he considered likely to benefit from psychotherapy to the therapist. But in the opinion of the therapist some of them were unsuitable for his treatment.

Names of ten referred cases were used as elements in a grid completed by each specialist. Each supplied eight constructs of his own, relevant to the question of whether the patients concerned should be referred. Afterwards each of them was supplied with the other's constructs, and finally a general construct, suitability vs unsuitability for psychotherapy, was supplied to both. In this way commensurate data were obtained. Their analysis revealed considerable differences in the specialists' opinion about what constituted suitability for psychotherapy, and helped to explain why some of the patients referred by the psychiatrist were unacceptable to the psychotherapist.

This experiment has important practical implications. Differences of opinion between specialists about suitability for referral for any kind of treatment may waste time and money.

Another case studied was that of a husband and wife who had come to the marriage guidance clinic for advice. Their marriage had never been consummated; attempts at sexual intimacy had caused them unbearable anxiety and they had gradually stopped trying altogether. For the past year they had slept apart.

The research psychologist saw the two together. They were very reserved. Finally an agreed set of elements was elicited from them, consisting simply of people: themselves, their parents, their parents-in-law, and a few other real and ideal characters. Terms referring to their sexual relationship were tabu. The therapist, after seeing the couple, defined the nature of their problem in his own conceptual terms.

The constructs supplied by the therapist and the elements supplied by the couple proved acceptable to all concerned, and each filled in a grid separately using them. They might be called hybrid grids since they were obtained by crossing terms taken from one construct system with terms taken from another. A fourth grid was completed by the psychologist using the same constructs and elements.

Combining them by construct produced an extended grid showing four locations for each element. The husband proved to be the element located at the most diverse places by different informants. He personally located himself particularly near the female elements in the grid. This suggested that the husband's role was the most ambiguous, and that he might possibly have some latent homosexual inclinations.

The treatment did not take account of this suggestion. It consisted simply in encouraging the husband and wife to talk freely about sex in the presence of the therapist; and eventually the couple resumed attempts at sexual intercourse which proved successful.

Conversely there are cases where agreement between two parties may seem dangerously close. A complete analysis of the relationships between two construct systems needs to take into account the areas of closest agreement as well as the areas of widest disagreement.

In spite of their diversity these experiments do not penetrate the acutest forms of disagreement, namely those where terms applied by one party are totally unacceptable to the other. To arrive at a method of comparing grids that have no constructs or elements in common the logical basis of grid technique needs to be examined.

The elements and constructs of a grid are related to each other logically as the subjects and predicates of propositions. The entry in each cell is a complete proposition. Thus the statement "Peter is a friend of mine" will be recorded in a grid by a positive entry in the cell where the column for "Peter" intersects the row for "my friends".

Therefore the two-way array of entries in a grid can be replaced by a single list of statements. No advantage is gained by doing so when all the data to be analysed belong in one grid obtained from a single informant; but when the conflicting opinions of two parties in dispute are to be compared reducing them to two lists instead of tabulating them in two grids has interesting possibilities. The two lists can be collated in one two-way array.

Let us suppose that *A* and *B* disagree acutely about a particular topic. Without consulting *B*, *A* prepares a list of the statements he believes cannot be ignored in discussing the subject. *B*, likewise, prepares his own list without consulting *A*. The two lists of statements need have no terms in common. They should not be too long—about a dozen statements in each would be sufficient. A's statements may be numbered a_1 to a_n, and B's, b_1 to b_m. Then a grid or array can be drawn up with n rows and m columns for comparing the statements. Each party is given a copy, and asked to fill it in, rating how far the other's statements agree with his own.

Table 1 shows a suitable grading scale.

TABLE 1

Grade	To imply that the two statements
+3	mean exactly the same
+2	mean about the same
+1	are rather similar
0	have no connection
−1	tend to disagree
−2	mean almost the opposite
−3	mean exactly the opposite

It is probably easiest for A to complete the grid by row, grading each of B's statements in turn for equivalence to his own; while B completes the grid by column, following the same procedure. The two grids, **A** and **B**, can be added together without any preliminary processing, to form the *Dual* grid:

$$\mathbf{U} = \mathbf{A} + \mathbf{B}$$

The entry in any particular cell of **U**, say u_{ij}, will show A's and B's combined estimate of the equivalence between A's statement number i and B's statement number j.

An example

The construction of a *Dual* grid was not proposed until the research project was nearly concluded. The time left was only enough to give it a laboratory trial.

The I.R.A. was chosen as a suitable subject for discussion. Margaret Hunter undertook to express the point of view of Irish Republicans and Paul O'Farrell the point of view of the Ulster Unionists. Hereafter they are called A and B, respectively. The statements contributed by each of them are listed in Table 2.

B seems to have felt under an obligation to concentrate on formulating statements with members of the I.R.A. as their subjects and terms applicable to them as constructs. A has exploited the freedom conferred by the instructions to produce a much more divergent set of statements. "Free Derry" is obviously acceptable: though it is in the grammatical form of an exclamation it can easily be paraphrased as a statement with which agreement or disagreement is possible. Incidentally the Emmett mentioned in a_3 was a leader of the 1916 rising who is reported to have said "Let no man write my epitaph till all Ireland is free", or words to that effect, in his speech after being sentenced to be hanged.

TABLE 2

A's statements (pro-I.R.A.)	B's statements (anti-I.R.A.)
1. The six counties were taken from Eire by force and force will return them.	1. Members of the I.R.A. are psychopaths.
2. The I.R.A. are fighting as much a war of liberation as the black guerrillas in Rhodesia.	2. Members of the I.R.A. have weak fathers.
3. No Irishman will be able to respect himself until Emmett's epitaph can be written.	3. Members of the I.R.A. enjoy destruction for its own sake.
4. It is only a question of time until English troops are withdrawn.	4. Members of the I.R.A. are wicked and should be eliminated.
5. Orangemen are a ludicrous anachronism.	5. The last thing an I.R.A. man wants is a united Ireland.
6. Orangemen are an embarrassment even to the English.	6. Religion is only an excuse for I.R.A. violence.
7. Free Derry.	7. Britain is responsible for the successes in Ulster industry and should govern Ulster.
8. Englishmen are the historical enemies of the Irish people.	8. Members of the I.R.A. are communists.
9. Ireland should be unified.	9. The I.R.A. resort to violence because they want power at any price.
10. The I.R.A. must have the support of the people or they would be unable to survive.	10. I.R.A. men are too lazy to work.

A's and *B*'s grids are presented separately in Tables 3 and 4; the *Dual* grid formed by adding them is given in Table 5.

No exhaustive general method for analysing *Dual* grids has yet been proposed. Much useful information was extracted from this one by examining the evidence; taking the contents of the statements and the comments of the participants into consideration as

TABLE 3

Equivalence grid completed by A

Pro-I.R.A. statements	Anti-I.R.A. statements 1	2	3	4	5	6	7	8	9	10
1	−2	0	0	−3	−3	0	0	0	2	0
2	−2	0	0	−3	−3	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	−3	0	0	−3	0	0	0	0	0	0
5	0	0	0	0	0	3	0	0	0	0
6	0	0	0	0	0	3	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	−3	0	0	0	0	0	0
9	0	0	0	0	−3	0	0	0	0	0
10	−2	0	0	−2	0	0	0	0	0	1

TABLE 4

Equivalence grid completed by B

Pro-I.R.A. statements	Anti-I.R.A. statements 1	2	3	4	5	6	7	8	9	10
1	−1	0	−3	−3	−3	−2	−3	1	2	0
2	−2	0	−3	−3	−3	−2	−3	2	2	−3
3	0	0	−1	−1	0	0	−3	0	0	0
4	0	0	0	0	0	0	−3	0	0	0
5	−2	0	−2	−2	0	0	−1	0	0	0
6	−2	0	−2	−2	0	0	−1	0	0	0
7	0	0	0	−1	−3	0	−3	0	0	0
8	0	0	0	−3	0	−2	−3	0	1	0
9	−2	0	−3	−2	−3	−2	−3	0	0	0
10	−1	0	−3	−3	0	0	0	1	1	−2

TABLE 5

A. Pro-I.R.A. statements	*B*. Anti-I.R.A. statements 1	2	3	4	5	6	7	8	9	10	Total Negative	Positive
1	−3	0	−3	−6	−6	−2	−3	1	4	0	23	5
2	−4	0	−3	−6	0	−2	−3	2	2	−3	21	4
3	0	0	−1	−1	0	0	−3	0	0	0	5	0
4	−3	0	0	−3	0	0	−3	0	0	0	9	0
5	−2	0	−2	−2	0	3	−1	0	0	0	7	3
6	−2	0	−2	−2	0	3	−1	0	0	0	7	3
7	0	0	0	−1	−3	0	−3	0	0	0	7	0
8	0	0	0	−6	0	−2	−3	0	1	0	11	1
9	−2	0	−3	−2	−6	−2	−3	0	0	0	18	0
10	−3	0	−3	−5	0	0	0	1	1	−1	12	2
Negative total	19	0	17	34	15	8	23	0	0	4	120	
Positive total	0	0	0	0	0	6	0	4	8	0		18

well as the amount of disagreement that they involve. The marginal totals of the negative entries for each row and column of the grid are particularly worth attention.

The column for b_4 has the largest. It disagrees to the maximum extent with a_1, a_2 and a_8; almost as much with a_{10}, and with all the other statements in A's list to some extent. In terms of their contents, statement

b_4 "Members of the I.R.A. are wicked and should be exterminated" disagrees completely with statements:

a_1 "The six counties were taken from Eire by force and force will return them"

a_2 "The I.R.A. are fighting as much a war of liberation as the black guerrillas in Rhodesia"

a_8 "The English are the historical enemies of the Irish people". It also disagrees strongly with statement

a_{10} "The I.R.A. must have the support of the people or they would be unable to survive"
and it disagrees with every other pro-I.R.A. statement to some extent.

These results suggest that the reply to the Ulster accusation that the I.R.A. is a gang of criminals is not given by one explicit statement but by a range of statements giving different reasons for considering that the I.R.A. are fighting for a good cause. We may venture to say that the major controversial issue between the two parties, denoted Issue 1, is

Whether the I.R.A. are a gang of criminals or are fighting for a good cause.

The nature of their cause is left unspecified.

Judged by their contents other less controversial anti-I.R.A. statements refer to this issue, viz. b_1, b_2, b_3, b_8, b_9 and b_{10}, which assert that members of the I.R.A. are psychopaths, have weak fathers, enjoy destruction for its own sake, are communists, resort to violence because they want power at any price and are too lazy to work.

The next most controversial of the Ulster statements is b_7:

Britain is responsible for the successes in Ulster industry and should govern Ulster.

Again there is not one Eire statement in particular which contrasts with this; most of them do, using various expressions to represent the activities of the English in Ireland in an odious light. a_5 and a_6 do not contrast so markedly with b_7, from which it would appear that the Orangemen are not closely identified with the English; and a_{10} which has no reference to the English in its content, is not rated as having any connection with b_7. Apparently the controversial issue concerned in these statements may be expressed as

Whether England is friendly towards Ireland, or hostile.

It can be denoted Issue 2.

None of the pro-I.R.A. statements is as controversial as b_4. The most controversial is a_1:

The six counties were taken from Eire by force, and force will restore them.

This has already been considered as a statement concerning Issue 1: it implies that the I.R.A. has a good cause for resorting to force. It goes further, and indicates that their cause is the re-unification of Ireland. Statement a_9, the next most controversial of the Eire statements:

Ireland should be unified

defines this cause explicitly without adducing it as an argument to justify the use of force. We may regard it as a separate issue, namely Issue 3.

Whether Ulster should continue to belong to the U.K. or become part of Eire

A fourth set of statements, concerning

Whether religious differences aggravate hostility emerges in statements b_6, a_5 and a_6, but it is not one that directly divides the two parties. b_6 belittles the importance of Roman Catholicism for the I.R.A. while a_5 and a_6 belittle the importance of

Protestantism for the Ulster Unionists. Since b_6 is rated in positive agreement with a_5 and a_6, both parties appear to agree that the importance of religious differences between them is exaggerated. This topic is hardly worth counting as a controversial issue.

A CONVERSATION BETWEEN THE PARTIES

The *Dual* grid was shown to the two parties at a meeting, and the conclusions which had been drawn tentatively from its analysis were explained. *B* was asked whether the four issues served to cover his anti-I.R.A. statements adequately, and *A* was asked the same question about the pro-I.R.A. statements. Both parties accepted this scheme for coördinating the two sets of statements, and agreed to go on to discuss the four issues.

It seemed reasonable to start the discussion with the issue which offered the best hope of securing an agreement between the two parties. In fact it did not take them long to reach agreement that the conflict between the I.R.A. and the Ulster Loyalists was not essentially a religious one, but rather a political one with which religious differences had become confused; so this issue could be shelved.

The next issue to be discussed was 2:

Whether England is friendly towards Ireland, or hostile.

It was pointed out that hostilities between England and France had persisted longer and been more bitter than hostilities between England and Ireland, yet they had been terminated by the Entente Cordiale and had since been almost entirely forgotten. Because relationships between Ireland and England had been hostile in the past was no reason why they should not be friendly in future.

The crucial issue was seen to be 3:

Whether Ulster should continue to belong to the U.K. or become part of Eire.

B was asked whether there were any conditions under which Ulster might consent to become part of Eire, and replied after some consideration, that it might do so on two conditions: if it were accorded Dominion status for an interim period of ten years or so; and if no preferential treatment was accorded to any religious sect (sc. the Roman Catholics).

The meeting concluded that if the political future of Ulster could be decided amicably in some such way the other issues would cease to be important. Religious divisions between Protestants and Roman Catholics would become less bitter and friendlier relations would develop between Ireland and England. Finally Issue 1 would be settled: the I.R.A.'s claim to be fighting for a good cause would be discredited and they would be deprived of popular support. If they did not disband voluntarily their activities would become more openly criminal and more effective measures could be taken to suppress them.

General discussion

The purpose of this paper, however, is not to offer a solution to the problem of the political future of Ulster. That problem was disclosed as the crucial issue during a discussion of the I.R.A.; and the I.R.A. had been introduced simply as a suitably controversial topic for trying out a proposed method for comparing two construct systems which could not be aligned. If the method has worked satisfactorily in this instance it may perhaps be considered validated to some extent; but its possibilities need to be examined more systematically.

More sophisticated methods of analysis are under consideration, but the interviewing technique needs further experimental trials first.

This paper is based on the results from a research into disagreement, which was supported by a grant from the Social Science Research Council between May 1976 and December 1977, and carried out in the Academic Department of Psychiatry, St George's Hospital Medical School, London. It was read to the Third International Congress on Personal Construct Psychology in July 1979.

Most of the work, including preparing the final report, was done by Margaret Hunter, who was appointed for the purpose. She was joined by Erica Rigg for part of the time. Several members of the department assisted. Final responsibility rested with Professor Arthur Crisp, as head of the department.

Reference

SLATER, P. (1977). *The Measurement of Intrapersonal Space by Grid Technique*, Vol. 2. London: Wiley.

ARGUS: a program to explore intra-personal personalities†

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This paper is based on the idea that we each have several "personalities" within us. An interactive computer program (ARGUS) is described which allows the user to explore his several personalities and the relationships between them. The program is seen as having a wide range of application, and two particular areas are developed in the present paper:
(a) the different rôles which the individual adopts, and
(b) the part played by "significant others" in the individual's construing.
The paper concludes with some suggested developments and applications.

Introduction

Unlike physical science, research in the social sciences changes the subject matter involved in the research. For instance, an experimenter and subject involved in work in the psychological field each interpret the situation as a special occasion where certain types of behaviour are acceptable. If this is not recognized and taken into account in the experiment, the results may be merely reflecting the experimental situation. Kelly (1955) suggested that each individual acts in the world in a similar way to a scientist, in that he builds theories of the world and validates or accommodates them in the light of his experiences of reality. Each personal scientist uses himself as participative subject matter and construes and interprets the results in a personally meaningful way. To do this effectively a conversational method must be used. A number of people have put forward models of "conversations". Luft (1961) used the "Johari Window" Fig. 1, which is a model of interpersonal awareness demonstrating the interaction of two variables "known/not known to self" and "known/not known to others".

Pask suggests that participants in a conversation cannot be regarded simply as distinct processors, but recognises an "M-Individual" or "mechanically characterized individual" which may be regarded as a biologically self-replicating system and is consequently a hardware distinction; and a "P-Individual" or "psychologically characterized individual" which "has many of the properties ascribed by anthropologists to a role" (Pask, 1975, p. 302), and is also a procedure executed in some M-Individual or processor and is therefore a software distinction.

† This paper is based on one presented to the Third International Congress on Personal Construct Psychology, Breukelen, July 1979.

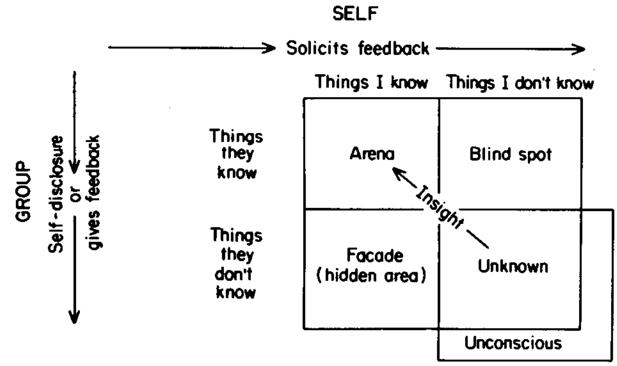

FIG. 1. The Johari Window.

Three aspects of conversation are therefore identified:

I. A conversation with oneself which may be generalized to a conversation between several P-Individuals each representing an important aspect of self.
II. A conversation between two P-Individuals in two distinct M-Individuals or processors.
III. A conversation in a group of M-Individuals which constitutes one or more P-Individual (see Shaw, 1980).

Type I Conversations

PEGASUS (*P*rogram *E*licits *G*rids *A*nd *S*orts *U*sing *S*imilarities) is an interactive computer program which elicits a repertory grid from an individual, simultaneously acting as a psychological reflector by heightening his awareness and deepening his understanding of himself and his processes. This is done by the provision of continual real-time feedback commentary on highly related elements or constructs, together with the encouragement to differentiate between them (see Shaw, 1978). ARGUS (*A*lternative *R*oles *G*rids *U*sing *S*ociogrids) is a development of PEGASUS in which the conversational domain is articulated through the computer within which a group of P-Individuals in one M-Individual can interact.

Gurdjieff (1975) said that we contain dozens of "I's", and Ouspensky (1957) recognized the variety of personalities in your head, as have many novelists (for example, Hesse, 1965). Ouspensky says (Ouspensky, 1957, pp 165–166):

> "I" is elusive and very small; it exists only as a potentiality; if it does not grow, false personality will continue to control everything. Many people make the mistake of thinking that they know which is which. They say "this is I", when in reality it is false personality. This is generally connected with our capacity to play roles. It is a very limited capacity; we generally have about five or six roles, whether we observe it or not. We may notice a certain, quite misleading, similarity between these roles and then, consciously or unconsciously, come to the conclusion that behind them there stands a "permanent individuality". We call it "I" and think that it is behind all manifestations, when in reality it is an imaginary picture of ourselves. This picture has to be studied.

Many schools of psychotherapy recognize the existence of different influences within one person, acted out in sometimes apparently inconsistent behaviours. Each of us knows from experience that we act as different people in different environments. The parent of the quiet, withdrawn child is amazed to hear what a noisy, aggressive child he is at school; that charming man who is always pleasant and attentive makes the life of his family miserable at home.

Communicating P-Individuals

It seems reasonable to hypothesis that a well-adjusted individual has recognized the existence of the personalities in his head, and allowed each a place to operate where it can be valued and made use of in the context of the whole person. People who seek psychotherapy may hold an inadequately communicating group of P-Individuals, therapy consisting in the creation of a conversation between these P-Individuals in which each may be recognized and valued. Such P-Individuals may be roles, purposes, or centres of attention, but all are significant points from which to view the world. In extreme cases these P-Individuals may not share any constructs in certain areas. This may be due to variations in the ranges of convenience of the constructs used, or perhaps distinct and disjoint P-Individuals are brought into operation in different universes of discourse. Lewin (1936) uses the phrase "plurality of separate spaces" to express this same idea. Wilson (1967) talks about "robots" which take over skilled activities such as typing which are so familiar and rigidly structured that they have become non-conscious, and has recently developed a theory of a "ladder of selves" (Wilson, 1978). Perhaps these robots are also P-Individuals. Another example might be to consider the lack of structure and the low test–retest reliability scores found in the grid performance of thought-disordered schizophrenics (Bannister, 1960, 1962; Bannister & Fransella, 1966) as due to the lack of enduring P-Individuals even over a short span of time.

This theory offers a possible explanation as to why we act differently on different occasions in apparently identical situations, which seems to concur with Kelly's general position. Psychotherapy offers the chance to set up a negotiation among one's own system of P-Individuals, and the P-Individuals introduced by the therapist. It enables the person to recognize that he can take different points of view and offers a meta-language in which to talk about the points of view. Different schools of psychotherapy tackle this in different ways. It would be interesting to explore the conversational ploys and techniques implicit in the psychotherapy of Rogers (1951), Perls (1969*b*) or Freud (1937) for example, in the terms of the development of both P-Individuals and the conversation between P-Individuals.

How can one identify such a system of P-Individuals in one brain? Ruesch refers to this type of system as "intrapersonal communication" (Ruesch & Bateson, 1951, p. 15):

> The consideration of intrapersonal events becomes a special case of interpersonal communication. An imaginary entity made up of condensed traces of past experiences represents within an individual the missing outside person.

One version of the ARGUS program is based on the assumption that if the concept of "ego ideal" or "superego" in the widest sense of interpretation has any validity, some of those P-Individuals are likely to be significant others in the past life of the person. A cathartic conversation can be initiated between "you as you are now" and the

P-Individuals which are the results of the influence of the significant others. By eliciting grids about the different P-Individuals more coherence may be achieved. These may be used as elements, the constructs describing the relationships of the P-Individuals, one to another. However, a more powerful tool involves the assignment of each construct to a perspective of one or more of these P-Individuals representing the influence of the significant others. So the P-Individuals are used both as elements in each grid, and as points of view from which each grid is elicited. Consequently, a grid is developed for each of the P-Individuals in the system, and the SOCIOGRIDS package maps out the commonality of construing between them. In this way the potential for conversation between the P-Individuals is made explicit and areas of concern uncovered. The movement towards a more coherent or actualized self is the aim of successful psychotherapy.

The grid elicitation is based on the MIN-PEGASUS version where no feedback is given on high matches during the process. Each construct is viewed from each point of view in turn and the elements rated as the elicitee thinks that person/role would have responded. Simultaneously, constructs are added which are felt to be important to each viewpoint. The final grids have the same element and construct names, but responses in the grid represent different perspectives and hence are not necessarily the same.

Analysis and interpretation

As previously noted (Shaw, 1979), Kelly's commonality corollary states that: "to the extent that one person employs a construction of experience which is similar to that employed by another, his processes are psychologically similar to those of the other person". This does not imply that this similarity is necessarily the totality of his psychological processing. Imagine an extreme case. In construing a certain topic individual *A* habitually uses four constructs while individual *B* habitually uses two. The constructs used by *B* are identical to two of *A*'s constructs. Now, when in conversation about this topic, *A* may be able to empathize totally with *B*, as *B* is using exactly the same construing as *A*, but *B* may not be able to empathize with *A* when *A* is using those constructs not common to *B*. The measure of commonality used in SOCIOGRIDS is sensitive to this situation; the mapping of grid *A* onto grid *B* produces a different degree of similarity from that of grid *B* onto grid *A*. Clearly if *A* and *B* are using constructs in the same way to order the elements then this will be revealed despite the verbal labels which have been attached to them. This technique can then be extended to investigate the commonality in a group of individuals by considering the overlap between every possible pair of grids. This is the basis of the SOCIOGRIDS program.

Each set of personal constructs represents that individual's thoughts and feelings about the universe of discourse. As these are expressions of the individual's construct system played out in this domain, ideas are tapped which the individual is bringing to bear on the subject.

A "mode" grid of the most commonly used constructs by all the individuals in the group is extracted and focused, exhibiting the content of the shared construing in the group. Each construct in the mode grid has been obtained from one individual in the group and is in no way changed when used in the mode. The mode order of the constructs is found from the previous calculations simply by looking, say, at construct 1 in grid 1 and finding the construct in grid 2 most like it, the construct in grid 3 most like it, and so on. An average of the match values found in this way gives a measure of the use of construct 1 in grid 1 by all the other people. This process is carried out for each construct in grid 1, then each construct in grid 2, until all the measures of use have been obtained. These are then ordered to produce the mode order of constructs, and the mode grid obtained by taking a suitable number of these off the top of the list. (This number is usually comparable to the number of constructs in the individual grids.) This grid then is not a consensus grid which averages out the individuality to produce a pale imitation of the group, but is strongly weighted towards the commonality or intersection of construing within the group. Due to this format the constructs tend to be highly clustered in the mode grid, and generally these clusters display a high degree of both literal and conceptual similarity in the construct labels as denoted by Duck (1973). In a field where more technical language is used it would be impossible for the non-expert to rely on his own judgement of what constituted literal and conceptual similarity. This seems a powerful technique for identifying such similarity by a more reliable process than has been used in the past (see Shaw, 1980). The mode grid can then be used as a common referent for the group with which each individual may be compared.

A sequence of sociometric diagrams designated "socionets" is produced from the matrix of similarity measures between pairs of individual grids. The highest related pair is picked out initially as a subgroup where commonality of construing occurs, followed by the subgroups defined by the rank ordering of all the similarity measures. This set of socionets shows those individuals in the group who have the most in common and those with unique viewpoints. The resulting six grids are therefore FOCUSed and processed on SOCIOGRIDS. The program maps out the relationships in the group, identifying the point of view which is central to the construing, and any subgroups which develop in the socionets sequence. The possible situations which have commonly been found to occur are the identification of an "isolate", and the development of two disjoint groups of P-Individuals. If a person splits his P-Individuals into two disjoint sets he may be increasing a tendency to schizoid thinking. This will inevitably add stress and discomfort to his ability to build adequate models and operate effectively in all aspects of his life.

Thus far, we have concerned ourselves with P-Individuals co-existing within a single person's head. Such a framework would seem to be readily applicable to the concept of "role" in psychology, and so it is to this concept that we now turn.

It is not unusual in the Social Psychology literature for the concept of role to be defined without reference to the individual who occupies the role. That is, a commonly-used definition of role sees it as a set of expectations held by other people about how the role incumbent will act. However, Personal Construct Theory sees behaviour as based on the person's own expectations (or constructs). Hence, from within Personal Construct Theory, a role implies a particular way of construing.

Given this, there are various ways we could proceed to investigate role behaviour. For example, McKnight (1977) has defined a particular role in terms of importance weights on a set of relevant constructs; in this view, constructs may be used identically (i.e. treat the elements in the same way) between different roles, but their relative importance changes with respect to each role.

For present purposes, however, there are two ways in which the ARGUS program can be seen to embody the concept of role. Firstly, we could use as elements the roles adopted by the elicitee in his everyday life. The constructs he uses whilst operating these roles are then elicited with respect to the roles themselves. Alternatively, in order to avoid the "closed-loop" nature of this exercise, elements could be chosen which lead to a wider sample of constructs, e.g. people known to the elicitee, other roles with which the elicitee interacts, interpersonal situations, and so forth.

Each of these two versions of ARGUS, that is, using "significant others" and roles as perspectives, since they use the same structure, involve only the contents of one brain, and the P-Individuals or personalities co-existing within that person. These two versions are merely examples of the many sets of P-Individuals which might be important to a person. The negotiation of a particular set for a particular occasion may be significant.

Applications

So far this technique has only been used for self-counselling with healthy, "normal", interested people, not with the seriously disturbed. It seems to be identifying areas of concern and possible past or future difficulties. If it were to be widely used in psychotherapy to assess the problems a client was experiencing, and to identify a possible starting point for conversation between the client and therapist, much more development might ensue. It may have applications in social work such as investigations into reasons for juvenile crime or misconduct. The roles could take the form of the youngster in different situations such as:

me when I'm with my friends
me at school
me at home with my parents
me at a football match.

Another application could be in areas of self-concept and self-esteem, or to investigate how a young person thinks the world expects him to be; or to help in the personal adjustment of discharged prisoners, long-stay hospital patients, or others moving into a new type of living. In industry, aspects of staff promotion and staff development may be made easier by using this technique to make explicit how a worker sees his future career, or to help him to cope with early retirement or redundancy.

An example of the use of this program was with a friend and colleague who was "normal" and well-adjusted, and not known to be suffering from any mental disorder. He was required to choose six (not necessarily distinct) roles in his life which were:(1) student, (2) teacher, (3) scientist, (4) therapist, (5) father, (6) son. The six grids were then elicited simultaneously from these six viewpoints respectively, and using these six roles as elements. The full results are shown in Shaw (1980).

The first 12 socionets are shown in Fig. 2, highlighting the problem the subject had with the role of "son". All other internal links are drawn in the group excluding "son" before any link brings in this role. The subject later commented that he had difficulty distinguishing between "son at the present time" and "adolescent son" making this perspective constantly shifting and unstable. From the various methods used to process these six grids, much data was produced which yielded a wealth of information. There was a high similarity between the grids from the different roles, indicating a well-adjusted and colloquially "together" person. The element "son" could have been usefully split into the two elements "son at the present time" and "adolescent son" so reducing the ambiguity of this position. Data from a psychotherapeutic patient may well

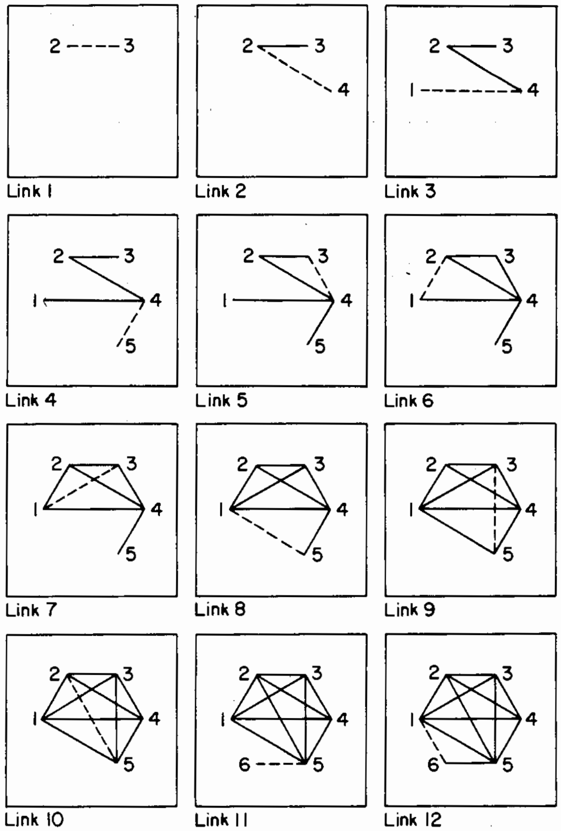

FIG. 2. The socionets.

reveal some more interesting aspects of this analysis and could exhibit explicitly the set of personally significant realities which would enable movement to be generated to allow him to operate more effectively in the world. Each of the six grids captures an important personal perspective for the elicitee. The patterning of the socionets offers him a frame of reference in which he can see himself and the relationship of the viewpoints which are significant in his life. It may then be possible to adjust slightly those relationships with which he has previously been unable to come to terms, and by using the Delphi technique (Pill, 1971) of iterating on the set of elicitations a more comfortable position may be attained from where he is better able to operate. Often a feeling of temporary maladjustment causes a person to become "out-of-sorts" or have "one of those days", when a review of his "self" and its constituent P-Individuals may be all that is needed. This technique offers that facility.

Agency and communion

Bakan has identified two aspects of living in the world both of which need to be satisfied (Bakan, 1966, pp. 14–15):

> I have adopted the terms "agency" and "communion" to characterize two fundamental modalities in the existence of living forms, agency for the existence of an

> organism as an individual, and communion for the participation of the individual in some larger organism of which the individual is a part . . . . Agency manifests itself in the formation of separations; communion in the lack of separations.

Salmon extends this distinction to child development (Salmon, 1977, p. 6):

> Agency involves purpose, separateness, control, activity, responsibility; communion involves sharing, widening personal boundaries, acceptance of things, love . . . . To me they offer interesting terms of comparison between the social realities in which children grow up . . . . When it comes to communion, it is important to know how far those close to a child share their inner experience with him, and expect him to share his with them.

In the Western society of business and commerce where timekeeping rules our lives, we crave for the communion of the Eastern religions. Relationships are struck and heavily invested in to provide the communion from which we feel deprived. However, they so often fail to satisfy the need, because the need is for a whole self, the self-actualized individual.

Luft describes relationships of "trust" and "tolerance" in terms of his Johari Window model, a feeling of trust being in Quadrant 1 but an attitude of tolerance being in Quadrant 2 (Luft, 1969, p. 138):

> If it is true that you can become more of what you potentially can become only in relationship with others, then we can understand how universal is the trust-relationship hunger. Trust means to be in a state of mutual and reciprocal interest and to be free to become. It is the sine qua non for self-actualization.

Maslow describes at length the characteristics of the self-actualizing person (Maslow, 1967, p. 67):

> Self-actualizing people do not for any length of time feel anxiety-ridden, insecure, unsafe; do not feel alone, ostracized, rootless, or isolated; do not feel unlovable, rejected, or unwanted; do not feel despised and looked down upon; and do not feel unworthy nor do they have crippling feelings of inferiority or worthlessness.

It would be interesting to see one of Maslow's self-actualizing persons run on the ARGUS program. One might expect a coherent map of relationships between the constituent P-Individuals in the conversation. Adequate communion is dependent on the recognition and acceptance of difference both within and between people. Perls (1969*a*) exhorts people to be aware that one person can never be part of someone else nor can someone else become a part of him/her. This seems to be the same as saying that communion takes place between accepted, distinct P-Individuals. The ARGUS program together with the SOCIOGRIDS processing of the results deepens the insight of a self by raising the awareness of the value of the "you's", enabling them to be recognized and accepted, and allowing the individual to overcome any feelings of resentment from past interactions.

Self-actualization may be the end-point of the solution to a space/time allocation problem of the P-Individuals sharing the M-Individual which is bounded by the skin; perhaps psychotherapy is the problem-solving procedure needed to achieve this state. Pask says (Pask, 1975, p. 303):

> The dual characterisations (M-Individual, P-Individual)... give rise to the notion that P-Individuals (cultural entities, minds) inhabit M-Individuals (processors able to interpret these procedures, and a fortiori, brains). It is legitimate though at first sight bizarre, to remark that developmental psychology is a study of how a P-Individual comes to be correlated with a vehicle which is a developing M-Individual. Odd though it sounds, this concept turns out to be useful, though it has not yet been properly exploited.

Psychotherapy may be seen as the initiation of a process of entering into communication with the significant others from one's past. Education may be seen as being concerned with the introduction of new P-Individuals, or the process of making existing P-Individuals more explicit and coherent. Industrial training may be seen as the introduction of new roles into the system of P-Individuals which are specific to the purpose and organization of the enterprise. ARGUS therefore has possible applications in other areas of human management in addition to psychotherapy. Rogers (1971) calls it learning to "become a person".

References

BAKAN, D. (1966). *The Duality of Human Existence: An Essay on Psychology and Religion.* Chicago: Rand McNally.

BANNISTER, D. (1960). Conceptual structure in thought disordered schizophrenics. *J. Ment. Sci.*, **106**, 1230–1249.

BANNISTER, D. (1962). The nature and measurement of schizophrenic thought disorder. *J. Ment. Sci.*, **108**, 825–842.

BANNISTER, D. & FRANSELLA, F. (1966). A grid test of schizophrenic thought disorder. *Br. J. Soc. Clin. Psychol.*, **5**, 95–102.

DUCK, S. W. (1973). *Personal Relationships and Personal Constructs—A Study of Friendship Formation.* New York: Wiley.

FREUD, S. (1937). *The Ego and the Mechanisms of Defense.* London: Hogarth.

GURDJIEFF, G. I. (1975). *Life is Real Only, Then When "I Am".* New York: Triangle Editions.

HESSE, H. (1965). *Steppenwolf.* Middlesex: Penguin.

KELLY, G. A. (1955). *The Psychology of Personal Constructs.* New York: Norton.

LEWIN, K. (1936). *Principles of Topological Psychology.* New York: McGraw-Hill.

LUFT, J. (1961). The Johari Window. *Hum. Rel. Train. News*, **5**, 6–7.

LUFT, J. (1969). *Of Human Interaction.* Palo Alto, California: Mayfield.

MASLOW, A. H. (1967). The good life of the self-actualizing person. *The Humanist* **XXVII**(4), 127–129, 139.

MCKNIGHT, C. (1977). Construing Others: A New Approach to the Study of Role and Role Conflict. Paper presented to the *Second International Congress on Personal Construct Theory*, Christchurch College, Oxford.

OUSPENSKY, P. D. (1957). *The Fourth Way.* London: Routledge & Kegan Paul.

PASK, G. (1975). *The Cybernetics of Human Learning and Performance.* London: Hutchinson Educational.

PERLS, F. S. (1969*a*). *In and Out the Garbage Pail.* Moab, Utah: Real People Press.

PERLS, F. S. (1969*b*). *Gestalt Therapy Verbatim.* Moab, Utah: Real People Press.

PILL, J. (1971). The Delphi Method: substance, context, a critique and annotated bibliography. *Socio. Econ. Plan. Sci.*, **5**, 57–71.

ROGERS, C. R. (1951). *Client Centred Therapy.* Boston: Houghton Mifflin.

ROGERS, C. R. (1971). *On Becoming a Person.* London: Constable.

REUSCH, J. & BATESON, G. (1951). *Communication: The Social Matrix of Psychiatry.* New York: Norton.

SALMON, P. (1977). Developing our construing of developing social construing. *Psychol. and Psychotherapy Association Forum*, **4**(1), 2–7.

SHAW, M. L. G. (1978). Interactive computer programs for eliciting personal models of the world. In FRANSELLA, F., Ed., *Personal Construct Psychology 1977.* London: Academic Press.

SHAW, M. L. G. (1979). Conversational heuristics for eliciting shared understanding. *Int. J. Man–Machine Studies*, **11**, 621–634.

SHAW, M. L. G. (1980). *On Becoming A Personal Scientist.* London: Academic Press.

WILSON, C. (1967). Existential psychology: a novelists approach. In BUGENTAL, J. F., Ed., *Challenges of Humanistic Psychology*. New York: McGraw-Hill.

WILSON, C. (1978). *Mysteries: An Investigation Into the Occult, the Paranormal and the Supernatural.* London: Hodder & Stoughton.

Construct heterarchies

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This paper presents a technique for deriving individual construct heterarchies, and for comparing several such without loss of sharpness in the initial act of constructing. It explains uses – both potential and in practice. The technique is related to Kelly's Personal Construct Theory, and some of its limitations and implications for that Theory are explained.

Introduction

The views of Kelly (1955), around which this issue of this Journal is developed, involve the personal creation of bi-polar constructs on which individual perceived elements are assumed to be located and which assemble together in a heterarchy leading to a small number of base constructs which are the key to the individual personality. While I doubt the universal validity of the bi-polar construct (see also Easterby-Smith, 1980)—especially for visual perception and when used in accounting for the act of design (which is the making of a new construct, which in itself, in Kelly's terms, requires a set of personal meta-constructs that permit the generation of a new personal construct and thus, also, of course, the generation of the personal construct heterarchy), the elegance and simplicity of Kelly's vision has lead to its extensive application through simple mechanization in various program suites, (Shaw, 1978, 1980; Shaw & Thomas, 1978; Slater, 1977, 1980; Bell & Keen, 1980; Leach, 1980; Easterby-Smith, 1980; Eshragh, 1980) that are often found useful and personally rewarding (to the user). The assumed bi-polarity of a construct has even been brought into doubt by one of Kelly's followers (Rosenberg, 1977), and I find no need to insist on it. The relaxation of this requirement brings Kelly's views of heterarchial concept organization closely into line with other constructivist psychologists—especially, of course, Piaget (1972), and also Pask's work on learning and knowledge (Pask, 1972; Pask & Scott, 1972, 1973; Pask, Scott & Kallikourdis, 1973; Pask, Kallikourdis & Scott, 1975).

However, the discovery of (representations of) such personal heterarchies is not necessarily easy. Piaget achieves it by himself analysing his notes of observations made over long periods and of many subjects. Kelly does it through an iterative process of questioning, which also takes a long time. His followers use various modifications (e.g. Fransella, in Fransella & Bannister, 1977), interviews subjects and elicits constructs and their ordering herself). Computerization speeds up the iterative process as demonstrated in other contributions to this issue, but may be somewhat limited—in that it is wholly reflective—and even Pask's learning machines take a long time and suffer (though progressively less so) from their similarly machine-bound imaginations.

† The work described in this paper was carried out, in the main, at the Architectural Association School, London.

Leaving aside the whole question of the bi-polarity of personal constructs, there remain two distinct technical problems that, although they have been resolved in various forms, could well be better resolved in practice. The first of these is the rapid generation of personal construct heterarchies, within a group of constructs. The second is the comparison of individual personal heterarchies of constructs—between common representations or between common heterarchial forms, without compromising the initial sharpness of individual constructs.

I propose a technique that goes some way towards this, and will discuss some of its implications and limitations not only in Kelly's terms, but also in terms of other constructivist theories, and I will introduce some apparent by-products of the technique.

TECHNIQUE†

The technique assumes a group of constructs (not necessarily bipolar) to be already chosen, but does allow for a portmanteau construct (usually denoted A) which represents the supra-ordinate construct "an important construct that's otherwise missing from the group". These are arranged in whatever manner is chosen, although experience suggests that arranging them—anagram-wise—in a circle is a good way, and this is the way we will used here (Fig. 1).

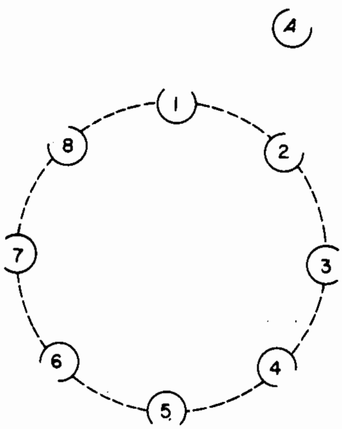

FIG. 1. A circle of eight constructs (here denoted by numbers), together with the portmanteau construct A, which is left outside the circle to highlight its role as covering something that is missing.

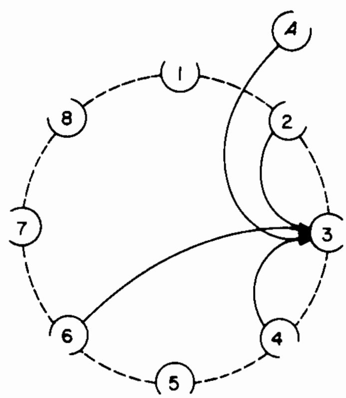

FIG. 2. A circle of constructs being filled in. The arrowhead points to the construct derived from the constructs at the bottom of the arrow stems. Note that more than one derivation may be possible, and that all derivations must be made from at least two other constructs.

Each construct in the circle (excepting, by choice, A) is then considered in turn, from the following point-of-view. It is assumed that construct generation (within the closed-system of the construct group) requires the interaction of at least two other constructs, as is a pre-requisite in Pask's (1975) productive relation between "topics-to-be-learnt", for the following, very commonsense reason: if one construct "topic", or one of the author's "Objects" (Glanville, 1975, 1978, 1980*a*) comes directly from another

† This technique has been described in a borrowed, variant form by Pask (1976). The variation is strange since Pask neglects his own rule for topic generation in not requiring at least two topics to entail another.

without the inclusion of some new information (necessarily from, in this closed-system, other constructs), it can only be the same as the single construct it is derived from (Fig. 2). Thus, a participant will consider whether each and every particular construct can be derived by some sort of (not necessarily, but possibly specified) interaction between two or more other constructs. The derivations specified are shown by an arrowhead, entering the derived construct, the shafts of which emanate from the constructs which, acting together, produce this construct. It is normal—even to be expected—that some constructs will be derivatives of other constructs, themselves derivatives of the first (double-bind), and that some will not be derivatives of any others at all.

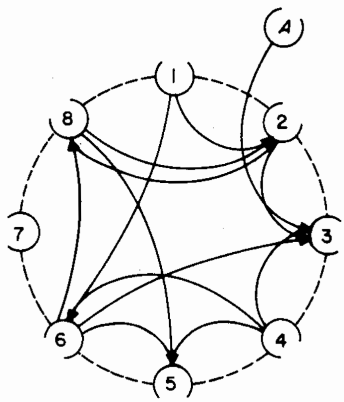

FIG. 3. A filled-in construct circle. Note that constructs A, 1 and 4 have no derivations and will be placed at the base level when the heterarchy is assembled, that there is a double-bind between 2 and 8, and that construct 7 is completely unconnected.

Having thus completed the interconnecting of the constructs in the circle, (Fig. 3), it is necessary to rearrange them to demonstrate the heterarchial structure of each participant's understanding. This is done according to the following procedure:

(i) Isolate out all constructs which have no arrowheads pointing into them, and lay them out upon a line at base level (L_0).

(ii) At the second level (L_1) place all those constructs derived only from those constructs on the base level.

(iii) At the third level (L_2) place all those constructs derived only from those constructs on the base and second levels.

(iv) Continue until there are no more constructs to be derived and place all constructs that appear as top nodes on the same top level, since the only meaning in the levels is within their own branches of the heterarchy (Fig. 4).

There may be four peculiarities that occur within the procedure which need special attention.

(a) Some constructs may not be connected in at all, (e.g. construct 7 in Fig. 3). These are not part of the participant's heterarchy, from which they are isolated. They may be omitted, left on the base line or tabulated separately, at will.

(b) The double-bind mentioned above may be encountered, where one as yet underived construct depends on another underived construct which in turn depends on the first. The normal way to handle this is to put all such constructs on the same level and

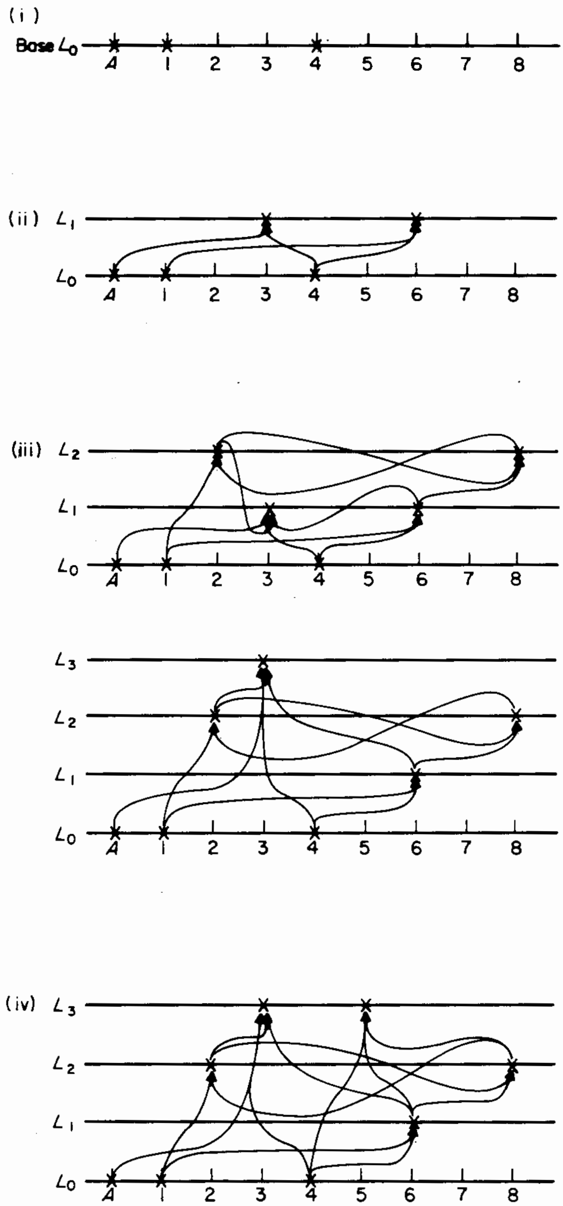

FIG. 4. The creation of the heterarchy from a construct circle, shown in four stages demonstrating the four instructions.

(i) Isolate out all constructs which have no arrowheads pointing into them, and lay them out upon a base line. (The unconnected construct, 7, is omitted.)

(ii) At the second level, place all those constructs derived only from those constructs on the base level.

(iii) At the third level, place all those constructs derived only from those constructs only on the base and second levels. Note the double-bind between 2 and 8, and the second (alternative) derivation of 3, which requires its level to change, as in the lower diagram, to the third level.

(iv) Continue with the derivation of construct 5 (which is derived from three constructs), and note that construct 3, which was raised to the third level since it had a derivation depending on constructs 2 and 6 already being derived, is also a point at the top of the heterarchy.

allow them to be used (together with already derived constructs on lower levels) to derive each other within the same level, (Fig. 5). Such an arrangement may even pertain on the base level. However, there is a justifiable argument that such a double-bind denotes a common but unelicited construct embedded within the constructs in the double-bind. Consequently, the double-bind may be broken by the insertion (on a

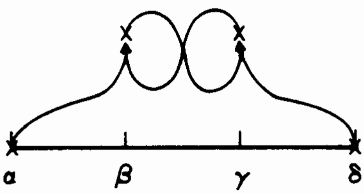

FIG. 5. The double-bind between β and γ, which is resolved by placing both on the same level.

lower level) of a new common construct, quite distinct from the supra-ordinate "spare" construct called A, and which may then be elicited and named, which, together with other constructs on other (lower) levels generates the two constructs that were in the double bind (Fig. 6). Note, however, that the elicitation of such a construct implies an expansion of the original circle of constructs and a possible consequent alteration of the derivative connections, which will in turn require a reformulation of the heterarchy and, possibly, further and novel double-binds.

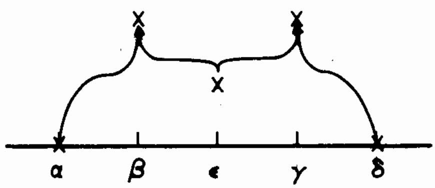

FIG. 6. The double-bind between β and γ, which is resolved by calling upon a new, common construct (ε) placed at a lower level.

(c) A construct may seem to need to appear at more than one level in the heterarchy. Should this be the case, it should always be placed at the higher level. All that has happened is that there are two or more derivations, one (confusingly) relatively simple and another depending on the prior derivation of a construct the simple derivation did not need.

(d) Under certain circumstances (only very rarely found) there are no underived constructs (i.e. ones without arrowheads entering them). In this case, the base level will consist only of double-bound constructs which are derived from but are also in their turn the derivation base of each other. This extraordinary event may be handled by the first double-bind technique. The second, requiring the assumption of sub-base-line constructs seeming a little esoteric. In the only case I have yet met, (Fig. 8(iii), where all constructs except A are on L_1), all constructs were bound to each other. The pathological condition that could create this sort of confusion will be mentioned later!

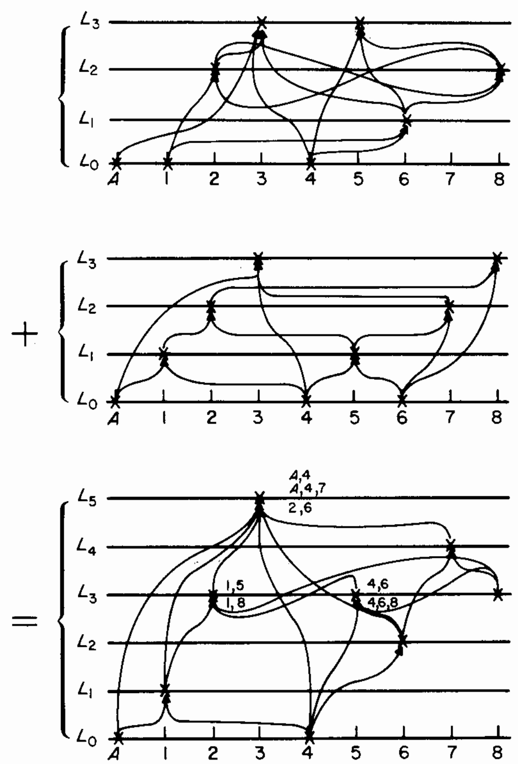

FIG. 7. Two heterarchies combined (alternative derivations are shown by the numbers of the constructs from which they are derived, rather than by separate arrowheads, which would in this case confuse the diagram). Each of the original heterarchies is a particular interpretation of the combined heterarchy, which also permits other, new heterarchies to be made. Note that the number of levels need not in all cases be the same.

Applications

There are three areas of application of this personal heterarchy generation technique.

The first is the obvious one, for which the technique was developed: the personal derivation of a personal heterarchy from a collection of elicited constructs. The technique presented here is reflexive, and distinctively sharp valued, and no more need be said about this application. The examples in Fig. 8 show various different personal derivations actually elicited from a supposedly (but actually dubiously) shared set of constructs.

The second is the social application. This may be thought of in two ways: the common form of heterarchies reflecting different constructs, and the common constructs reflecting different heterarchical forms.

Consider two heterarchies of identical form, but generated from constructs that inhabit different universes—say the universes of mechanical springs and electronic oscillators (an example beloved of Pask). Here the forms of two heterarchies match, but the names of the constructs are different. However, the workings of both are so similar that they are analogous to each other and may both be considered as alternative physical versions of the one abstract heterarchy—viz. oscillator theory. This is a special case, for it may not always be possible to establish similarities between the constructs in different heterarchies with the same form. But it may be, and anyhow the form itself has something to tell us, as we will discover in the third application.

When the constructs are held in common, in name at least, the difference in the form of the individual heterarchies shows up different points-of-view. As such, each heterarchy shows an individual compilation of knowledge. These may be thought of on individual realizations of an Entailment Mesh (Pask, Scott & Kallikourdis, 1973; Pask, Kallikourdis & Scott, 1975; Pask, 1975), that is as Entailment Structures, and their relatedness may be computed by considering each heterarchy as a different unfoldment of a category, (e.g. Ginali & Goguen, 1977; Open University Course Team, 1976, and also Leach, 1980). Being able to look at a collection of such construct heterarchies can also help determine the underlying assumptions made by several individuals and hence of what are conventionally thought of as their semantic networks (e.g. Katz & Fodor, 1963; Winograd, 1972). This is obviously valuable when, for instance, there are irreconsilable differences, beyond negotiation, in industrial disputes, although any similar heterarchy generating technique could be used. The particular advantage of the technique presented here is that the initial sharpness is not lost, and the heterarchy generation is personal.

The comparison of construct derivations has, however, another social application when a collection of these heterarchies is used together. Consider, for a moment, how several textbooks of some common subject differ. It is not that the things-to-be-learned are particularly different (although there may be some differences in terminology and certain fringe topics may not be universally included): rather, it is their precise interconnection and logical development. We normally refer to this as "difference in perspective". There is nothing inherently right or wrong in any of these arrangements: they are potentially valid alternatives, and may, of course, be set up as such, allowing each individual learner to follow whatever bit of whichever argument he finds more appealing.

For some years Pask has used such alternative structurings of fields of knowledge, which are called "Entailment Structures" and are particularized versions of rather more general (and circular) "Entailment Meshes". The problem, however, with this technique is that a researcher has to extract the argument from several textbooks, and the learner cannot modify this arrangment. The technique given here allows a far simpler way of sharing the alternative arguments—that is, of course, of showing alternative construct generation and derivation heterarchies. That such alternatives are useful, Pask has shown. Imagine, for instance, trying to compose a manual on how an internal combustion engine works: the complexity of construct connectivity is considerable and to trim this to fit one overview is thoroughly risky because the particular way one person does it may be virtually incomprehensible for another, (Fig. 7).

The third application is rather more arbitrary. It appears to be the case, but the only reason I can give for it being so is purely speculative.

If personal heterarchies are examined, they appear to demonstrate characteristics of each person's learning ability. Take, for instance, the examples shown. To me, as the teacher of the students who produced them, they reflect precisely the problems I noticed each suffering in trying to execute an architectural project, as shown in the captions to Fig. 8. Such a judgement is, of course, quite subjective but I am not certain how that limitation can be overcome—or even whether it should be.

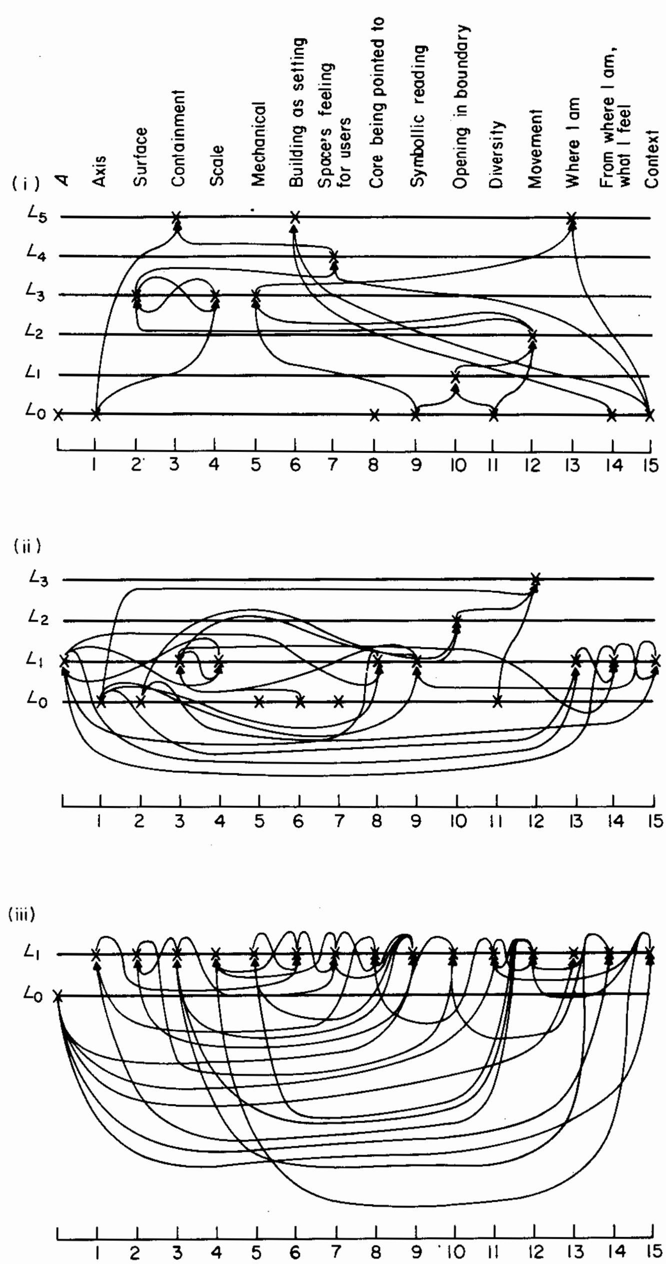

FIG. 8. Three heterarchies of a common subject matter generated by architecture students. Note the considerable difference in form, and the manner in which the reflect learning abilities.

(i) This student's learning was characterized by being relatively straightforward, but had the weakness of trying to please too many people at once.

(ii) This student started well, but, at a point in the middle of a project would get confused and overcomplicate things. If this stage was passed, there was a happy outcome and a good project.

(iii) This student could never get beyond the stage of having an idea and going away to consider it, as a result of which many objections were found, and some other idea would be grasped at. The student did not complete the course.

My explanation of why these heterarchies might reflect learning ability is that, where there are many constructs double-bound, there is a problem of having too much to handle at once (along the lines of Miller's (1956) argument on short-term memory and informative processing), or alternatively, of having to invent sub-constructs which split the double-bind; and that, where there are too many top points in the heterarchy the student is involved in a too-distributed set of goals which is, again, informationally unmanageable. Of course, the extra ordinary student for whom everything is interconnected (Fig. 8(iii)) has a problem very akin to the (as yet fictitious) one for whom none are connected—where do you begin and what connection do you follow—a terrifying problem when looked at in this manner.

Practice

So far, in practice, this technique has been used on four different occasions.

The first occasion, for which the technique was invented, was the analysis of a study syllabus for an architecture course in which the experimenter selected important terms from an international manifesto prepared by the teaching staff, and invited both students and staff to demonstrate their heterarchies. In fact, this was found to be very difficult, because the anagram circle technique had not been incorporated, and the need for construct generation by construct interaction was found to be hard to understand and even harder to remember in use. Furthermore, it was found that selection by each individual from the experimenter's initial selection of the terms that were significant to each of them meant that not only were the heterarchies difficult to extract, they were also consituted of such different terms that about the only thing which could be said of them was that each participant had a unique and distinct interest.

For the second occasion, the names of the constructs were much more rigorously determined by the group (Glanville, Jackson & Pedretti, 1979). Furthermore, the anagram technique had become incorporated. As a consequence, it was much easier to derive and compare the heterarchies. It was on this occasion that the reflection of learning became apparent, and this paper has been illustrated mainly with examples taken from this use.

The third occasion was Pask's use where, from several heterarchies, he does indeed build up entailment meshes, and persuades participants to debate the relevant validity and generalizability of their various heterarchies.

Finally, the technique has been used to generate a symposium syllabus by using the heterarchies that various participants at an earlier symposium (on self-reference) made of a collection of already debated named constructs.

On all occasions except, perhaps, the first, the technique has been found useful and rewarding.

Conclusion

This paper has presented a technique for deriving individual construct heterarchies, and for comparing several such without loss of sharpness in the initial act of construing, and has explained uses—both potential and in practice. The technique has been related to Kelly's Personal Construct Theory, and some of its limitations and implications for that Theory explained.

Kathryn Findlay first required the invention of this technique. Heinz von Foerster suggested the anagram form.

References

BELL, R. C. & KEEN, T. R. (1980). A statistical aid for the grid administrator. *Int. J. of Man–Machine Studies*, **13**, 143–150.

EASTERBY-SMITH, M. (1980). The design, analysis and interpretation of repertory grids. *Int. J. of Man–Machine Studies*, **13**, 3–24.

ESHRAGH, F. (1980). Subjective multi-criteria decision making. *Int. J. of Man–Machine Studies*, **13**, 117–141.

FRANSELLA, F. & BANNISTER, D. (1977). *A Manual for Repertory Grid Technique*. London: Academic Press.

GINALI, S. & GOGUEN, J. (1977). A categorical approach to general systems. In KLIR, J. (1978). *Applied General Systems Theory*. New York: Plenum.

GLANVILLE, R. (1975). The Object of Objects, the Point of Points: or—Something about Things. unpublished Ph.D. Thesis, Brunel University, Uxbridge.

GLANVILLE, R. (1978). What is Memory that it can remember what it is? In TRAPPL, R. & PASK, G. eds, *Progress in Cybernetics & Systems Research*, Vol. 4. *Proceedings of the 3rd EMCSR, Vienna, 1976*. Washington: Hemisphere.

GLANVILLE, R. (1980*a*). Consciousness—and so on. In *Proceedings of the 4th EMCSR*, Washington: Hemisphere. 1978 forthcoming, and *Journal of Cybernetics*, forthcoming.

GLANVILLE, R. (1980*b*). The Model's Dimensions—a Form for Argument. Paper presented to 4th WOGSC, Amsterdam, to appear in *Int. J. of Man–Machine Studies.*

GLANVILLE, R. & JACKSON, P. (1980*c*) The theory of Model Dimensions applied to Relational Data Bases. Paper presented to 4th WOGSC, Amsterdam, to appear in *Int. J. of Man–Machine Studies.*

GLANVILLE, R., JACKSON, P. & PEDRETTI, A. (1979). Ruing & Construing. In *Proceedings of the SGSR Silver Jubilee Meeting, London, 1979*. New York: Springer.

KATZ, J. & FODOR, J. (1963). The structure of a semantic theory. *Language* **39**, 170–210.

KELLY, G. (1955). *The Psychology of Personal Constructs*, Vols 1 & 2. New York: Norton.

LEACH, C. (1980). Direct analysis of a repertory grid. *Int. J. of Man–Machine Studies*, **13**, 151–166.

MILLER, G. (1956). The magical number seven, plus or minus two. *Psychological Review* **63**. Reprinted in MILLER, G. (1970). The Psychology of Communication. Middlesex: Pelican.

OPEN UNIVERISTY MATHEMATICS COURSE TEAM. (1976). *Categories & Universal Objects*. Milton Keynes: Open University Press.

PASK, G. (1972). A fresh look at cognition & the individual. *Int. J. of Man–Machine Studies*, **4**, 211–216.

PASK, G. (1975). *Conversation, Cognition & Learning*. New York: Elsevier.

PASK, G. (1976). *Conversation Theory: Applications in Education & Epistemology*. New York: Elsevier.

PASK, G. & SCOTT, B. (1972). Learning strategies and individual competence. *Int. J. of Man–Machine Studies*, **4**, 217–253.

PASK, G. & SCOTT, B. (1973). CASTE—a system for exhibiting learning strategies & regulating uncertainty. *Int. J. of Man–Machine Studies*, **5**, 17–52.

PASK, G., SCOTT, B. & KALLIKOURDIS, D. (1973). A theory of conversations and individuals (exemplified by the learning process on CASTE). *Int. J. of Man–Machine Studies*, **5**, 443–566.

PASK, G., KALLIKOURDIS, D. & SCOTT, B. (1975). The representation of knowables. *Int. J. Man–Machine Studies*, **7**, 15–134.

PIAGET, J. (1972). *Psychology & Epistemology*. New York: Viking.

ROSENBERG, S. (1977). Analysis of Personal Constructs in Person Perception. Notes on a workshop given at the *2nd International Congress on Personal Construct Theory*, Oxford. In FRANSELLA, F., ed. (1978). *Personal Construct Psychology 1977*. London: Academic Press.

SHAW, M. L. G. (1978). Interactive Computer Programs for Eliciting Personal Models of the World, In FRANSELLA, F. ed. (1978). *Personal Construct Psychology 1977.* London: Academic Press.
SHAW, M. L. G. (1980). *On Becoming A Personal Scientist,* London: Academic Press.
SHAW, M. L. G. & THOMAS, L. F. (1978). FOCUS on education—an interactive computer system for the development and analysis of repertory grids. *Int. J. of Man–Machine Studies,* **10**, 139–173.
SLATER, P. (1977). *The Measurement of Intrapersonal Space by Grid Technique,* Vol. 2. London: Wiley.
SLATER, P. (1980). Construct systems in conflict. *Int. J. of Man–Machine Studies,* **13**, 49–57.
WINOGRAD, T. (1972). *Understanding Natural Language.* New York: Academic Press.

Appendix

NOTE ON THE DISAMBIGUATION OF SOME POTENTIAL GRAPHIC AMBIGUITIES

It has been pointed out to me by Gordon Pask, since this paper was first published in the International Journal of Man-Machine Studies (Vol. 13, 1980) that there is an ambiguity in some of the figures—specifically Figs. 2, 3, 4, 7 & 8.

This ambiguity comes about after the event. That is to say, the ambiguity is not in the figure (or the procedure for its production) as it is made, but it becomes apparent when the figure is looked at as a finished object, from an external point of view. This ambiguity is graphical in origin, and may be simply overcome. If you look at Fig. 2, you will notice the arrows entering the construct labelled 3 have become ambiguous. It is simply hard to know from which other constructs 3 derives, and how many different derivations there are. This graphical problem is almost bound to occur. Another difficulty may be in sorting out which arrow shafts are which. But, equally, the act of filling out the form is not ambiguous, and is a procedure that is both enjoyable and relatively hard to cheat, for the method of transforming from the circle into the heterarchy is by no means obvious or simple. Thus, it is worth keeping the form, but also recording some further information when the form is being filled in, to remove the ambiguity, viz. the numbers of the constructs that produce whichever construct you are interested in. So that, by construct 3 in Fig. 2 should be recorded A, 4 and 2, 6. (If the means of combination/interaction of the constructs is being considered, that may also be recorded, viz. $A \wedge 4, 6 \rightarrow 2$.)

This sort of ambiguity also pertains in a similar manner in the heterarchical figures e.g. Fig. 4iv (the heterarchy of the circle filled-in in Fig. 3, which is the completed version of Fig. 2) is ambiguous in its cold state as a graphic object, and even I, the heterarchy's creator, had difficulty in sorting out the derivations of the same construct 3. The full scale of this potential ambiguity may be seen in Fig. 7, particularly Figs. 7ii and 7iii. The solution to this problem is of course anticipated in Fig. 7, where in adding two separate heterarchies the result had to be shown without graphic representation of the separate derivations which are notated by writing them by each construct. Thus construct 7 has the three derivations A, 4 and A, 4, 7 and 2, 6.

This slight addition to the notational task should remove the ambiguities.

New directions in the analysis and interactive elicitation of personal construct systems

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The computer elicitation and analysis of personal construct systems has become a technique of great interest and wide application in recent years. This paper takes the current state of the art as a starting point and explores further developments that are natural extensions of it. The overall objective of the work described is to develop man–computer symbiotic systems in which the computer is a truly dialectical partner to the person in forming theories and making decisions. A logical model of constructs as predicates applying to elements is used to develop a logical analysis of construct structures and this is contrasted with various distance-based clustering techniques. A grid analysis program called ENTAIL is described based on these techniques which derives a network of entailments from a grid. This is compared and contrasted with various programs for repertory grid analysis such as INGRID, FOCUS and Q-Analysis. Entailment is discussed in relation to Kelly's superordination hierarchy over constructs and preference relations over elements. The entailment analysis is extended to rating-scale data using a fuzzy semantic model. The significance of Kelly's notion of the opposite to a construct as opposed to its negation is discussed and related to other epistemological models and the role of relevance. Finally, the interactive construct elicitation program PEGASUS is considered in terms of the psychological and philosophical importance of the dialectical processes of grid elicitation and analysis, and recommendations are made about its generalization and extension based on the logical foundations described. Links are established between the work on repertory grids and that on relational data bases and expert systems.

1. Introduction

It is now 25 years since Kelly (1955) published his seminal book on personal construct theory. It provides a remarkably far-reaching and well-structured foundation for epistemology. His work is anchored very firmly both in its close correspondence to the actual behaviour of people and in its coherent and consistent philosophy. This is not to say that Kelly fully worked out a logically, philosophically and psychologically complete model of knowledge acquisition. His attempts to link his work to other philosophical studies of epistemology, his attempt to present it axiomatically, and his embodiment of it as an empirical tool through the repertory grid, are all incomplete. They need much further development and modification to take them to levels of scholarship, science and technology which would allow them to stand critical comparison with related work.

However, there are now many who would endorse Kelly's intuition for what he proposed as a starting position: his model of the *personal scientist* acquiring a personal model of his world; and his idea of *constructs* as personally developed templets needed to filter perception in order to allow past experience to relate to future behaviour. Many would now agree that these provide adequate foundations for a true psychological epistemology well-grounded philosophically and capable of being developed into both theory and technology.

In the quarter of a century since the publication of Kelly's book there have been many developments that relate to it and form a basis for a fresh impetus during the next 25 years. In philosophy the balance has been struck between the extremely personal epistemologies of the existentialists and the extremely impersonal epistemologies of the logical positivists. Attempts, such as those of Ayer (1936), to define precisely the one acceptable method of legitimating belief have died down, and Kelly's constructive alternativism has become fashionable in conventionalist and pluralist positions such as those of Gellner (1974) and Feyerabend (1975). In Kelly's work we can find incorporated both Kuhn's (1962) emphasis on the importance of the paradigm and hence the possibility of revolutionary changes in viewpoint, and Popper's (1972) emphasis on falsifiability as the prime test of meaningful belief. Modern philosophy has swung the focus of attention from science to the scientist, a viewpoint which makes Kelly's work now appear central to the key issues.

Positivist science advanced as rapidly as it did because of its very close links with formal logic. Kelly himself was probably influenced by this in his attempt to present his own position axiomatically as a "fundamental postulate" and a set of 11 "corollaries". However, the possibility of forming logical foundations for his theories, let alone axiomatizing them, was not within the realms of the mathematics open to him at the time. His concept of a *construct* applied to *elements* and having a *range of convenience* requires a modal logic incorporating notions of relevance, and the theory underlying these was only formalized during the mid-1960s (Snyder, 1971; Anderson & Belnap, 1975). The formalization of modal logic has been very fruitful in establishing semantic foundations for natural language (Cresswell, 1973), and its basis in the concept of *possible words* (Lewis, 1973; Bradley & Swartz, 1979) seems very close to the model that Kelly needed for the dynamics of construct formation and modification. A related development in recent years has been that of multivalued logical foundations for set theory such as Zadeh's (1976) *fuzzy logic*, and the application of this also to modelling human semantic processes has much in common with Kelly's approach.

Neither the philosophical nor the logical developments would be of value unless interest in Kelly's work had been developed and sustained during the past 25 years. This has come about largely through its clinical applications (Slater, 1976) and its integration into the mainstream of work on personality (Bannister & Fransella, 1971; Hogan, 1976). Because of the experimental nature of much of this work the analysis of Kelly's repertory grids through computer programs has itself become a significant line of development (Shaw, 1980). The on-line application of computers to operationalize Kelly's construct theory and to reflect to an individual his role as a personal scientist adds a new dimension to the work. We can see the beginnings of the *man–machine symbiosis* (Licklider, 1960) promised in the early days of computing, in which the logical processing power of the computer is used to complement the creative imagination of the person.

Shaw's (1980) PEGASUS was one of the first available computer programs to elicit personal construct systems interactively whilst at the same time feeding back the results of analysis and directing further elicitation through this. It has been widely used in a variety of educational, clinical and managerial applications. In this paper we attempt to draw out of the current programs those features which seem of greatest value and project them to the next stage of development. This entails the use of recent developments in logic and semantics to give rigorous and operational foundations for Kelly's notions of the construct system of the personal scientist. New methods of analysis of repertory grid data are defined and the results compared with previous analyses. The extension of PEGASUS to be a truly dialectical partner to a person in forming theories and making decisions is proposed.

2. Construct structure and analysis

Kelly put forward "personal constructs" as filters through which we perceive events (Kelly, 1955, pp. 8–9):

> Man looks at his world through transparent templets which he creates and then attempts to fit over the realities of which the world is composed.

He continually emphasizes the epistemological status of these constructs in predicting and controlling the world and their ontological status as personal conjectures rather than reality-derived absolutes (Kelly, 1955, p. 14):

> Constructs are used for predictions of things to come, and the world keeps on rolling on and revealing these predictions to be either correct or misleading. This fact provides the basis for the revision of constructs and, eventually, of whole construct systems.

When it came to the formal and practical representation of constructs Kelly took them to be binary in nature such that each event construed was classified as belonging to one "pole" of a construct, or the other. In essence Kelly placed the same fundamental emphasis as did Spencer Brown in his seminal work, *Laws of Form*, on the human, creative operation of "making a distinction" (Spencer Brown, 1969, p. v):

> The theme of this book is that a universe comes into being when a space is severed or taken apart.... By tracing the way we represent such a severance, we can begin to reconstruct, with an accuracy and coverage that appear almost uncanny, the basic forms underlying linguistic, mathematical, physical and biological science, and can begin to see how the familiar laws of our own experience follow inexorably from the original act of severance.

It casts an interesting light on the further development of Kelly's work that Spencer Brown goes on to use the notion of a distinction to develop a logical "calculus of distinctions" with fewer primitives than the classical propositional calculus which he claims avoids the paradoxes of previous approaches. In his own practical development of a personal construct technology through the "repertory grid" and the extraction of "factors" from it Kelly treats constructs as if they gave a vector of measurements of the event rather than a logical representation of it. This approach seems to have been followed also by all later workers on the analysis of the repertory grid through a variety of methods such as principal components analysis. In the following sections we show that the analysis of construct systems as *logical structures* both encompasses many of the advantages of such methods and also leads to interesting new directions of analysis.

The central part of this paper deals with the analysis of the grid rather than its elicitation and it is worth emphasizing at this stage that our prime motivation for the form of logical analysis developed here was to extend techniques for the interactive elicitation of grids through feedback of the analysis. We have been aiming to develop a *conversational, dialectical* system of computer programs for the *self-reflective* study of one's role as a personal scientist. With this in mind it has been important to develop forms of analysis that can support a conversation by commenting upon its contents without introducing new constructs beyond those the user already employs. It is this which has led us to a logical analysis in which the *meta-language* used for comments on construct structures is essentially the same as the *object-language* in which the information defining these structures is given.

Section 3 reviews the main current distance-based grid analysis techniques INGRID and FOCUS together with the more recent Q-Analysis. Section 4 develops a logical model of a repertory grid and the notion of *entailment* between the poles of constructs. Section 5 describes a program, ENTAIL, that extracts such entailments from grids and gives a comparison of some results with those of the distance-based methods. Section 6 extends the analysis to consider the strength of entailment and section 7 relates it to the subordination/superordination hierarchy. Section 8 shows how a similar asymmetric analysis may be applied to the element structure, section 9 extends the analysis to grids with more than two values through a *fuzzy semantic* model, and section 10 further extends it to compound predicates. Section 11 introduces the special features of interactive grid elicitation, and section 12 shows how the dialetical nature of such a conversational process is related to the logical anlysis and the enhancement of the results obtained. Section 13 gives a series of recommendations for the direction of further work and section 14 concludes the paper.

3. Distance-based grid analysis

Figure 1 is a repertory grid from Shaw (1980, p. 79) showing Jane's allocation of 12 acquaintances to the poles of eight constructs. It is a particularly good illustrative example because Jane has given far more background explanation to the poles of her constructs than is usually available and this makes it easier to assess the prima facie *meaningfulness* of any analysis. The only difference between Fig. 1 here and Fig. 6.4 in the book is that Shaw uses the letter "X" for the assignment to the left-hand pole and the letter "O" for the assignment to the right-hand pole, whereas we have used the numbers "1" and "0", respectively. This change to numerals is deliberate because we wish to examine how the values in the grid may be viewed in two ways: firstly as numerical values; and then as logical values.

We will concentrate initially on the relations between the constructs in a grid such as that shown in Fig. 1. For any given construct we may regard the numbers in the grid as a *vector of values* giving the assignment of each element in turn to one or other of the poles of the construct. From this point of view each construct becomes represented as a point in a multi-dimensional space whose dimension is the number of elements involved. The natural relation to examine between constructs is then the *distance* between them in this space. Two constructs which are zero distance apart are such that all elements are construed in the same way in relation to them and hence we might infer that they are being used in the same way—in some way they are *equivalent* constructs. For constructs which are not equivalent we may analyse the entire constellation in space to determine a set of axes such that the projection of each construct onto the first axis accounts for most of the distance between them, the projection on the second axis

			ELEMENTS											
	1	0	1	2	3	4	5	6	7	8	9	10	11	12
C1	*Intensity*. They both are interested in other people. Concerned with world problems. Ambitious. Slightly detached.	*Humorous*. Creative. Unconventional approach to work & relationships. Exciteable.	1	1	0	0	1	0	0	1	0	1	0	0
C2	*Individualistic*. Musical. Calm (exteriorally). Unconventional. Non-aggressive. Loyal. Interested in myth & fantasy. Homely. Landloving. Tending toward introversion. Unusual humour.	*Self aware*. Controlled. Sporting. Experienced in relationships. Attracted to sophistication & the exotic. Extroverted. Light hearted.	0	0	0	0	1	1	0	0	0	0	1	0
C3	*Generous*. Interested in history. Slow living. Perfectionist in work. Unusual relationships.	*Direct*. Political. Super active. Strong integrity. Committed.	0	0	0	0	1	1	1	0	1	0	1	0
C4	*Ambitious*. Questioning. Quick minds. Confident. Interested in "societies ills."	*Artistic*. Capable. Gentle. Romantic. Exploratory.	1	1	1	1	0	0	0	1	0	1	0	1
C5	Outdoor enthusiasts. Anxious to succeed. Anxious about success with other sex. Active. *Enigmatic*. Need mental stimulation.	Creative. *Enjoys comfort*. Relaxed.	1	1	1	1	0	0	0	1	0	0	0	1
C6	Enjoy intellectual discussion. Difficult to understand initially. City livers. *Seek challenges*. Insecure backgrounds.	Affectionate. Humble. Sensitive. Musical. Involved with those immediately around. *Compassionate*. Philosophical.	0	1	1	1	0	0	1	1	1	1	0	1
C7	Energetic. Sociable. Politically concerned interests. *Dynamic*. Restless. Factual approach as opposed to interest in fantasy world.	Thorough. *Care for detail*. Extremely creative. Not concerned with social success. Gentle. Perceptive.	1	1	1	1	0	0	0	1	1	0	0	1
C8	Both need company. *Gregarious*. Prepared to compromise. Factual approach. Enjoy discussion.	Musical. Scientific but also keen on the "unreal" world. *Fantastical*.	1	1	1	1	0	0	0	1	1	1	0	1

FIG. 1. Jane's repertory grid.

accounts for most of the remaining distance, and so on. This is a *principal components analysis* of the construct space (Slater, 1977). We may also group constructs together that are close together in space using a variety of techniques. These are all some form of *cluster analysis* (Duran & Odell, 1974).

All of the techniques based on such a numerical spatial view of construct structures depend on the notion of constructs being equivalent if they are represented by the same point in space and somehow *nearly equivalent* if they are represented by points close to one another. Principal components analysis goes even further and assumes that the distances between points are themselves meaningful and that the distribution of points in space gives an indication of meaningful directions in that space. However, it is most often used just as a basis for clustering constructs according to their distance apart on the two principal dimensions so that the notion of the "meaning" of these dimensions does not necessarily arise.

The grid of Fig. 1 was analysed using Slater's (1977) INGRID program for determining the principal components. Figure 2 shows the twelve elements and the two poles of each of the two constructs plotted against the first two principal components. In this section we will concentrate on the construct analysis and treat the elements analysis later in section 8. It can be seen that the left-hand poles of constructs 4, 5, 7 and 8 form a fairly tight cluster together with the right-hand poles of constructs 2 and 3. The

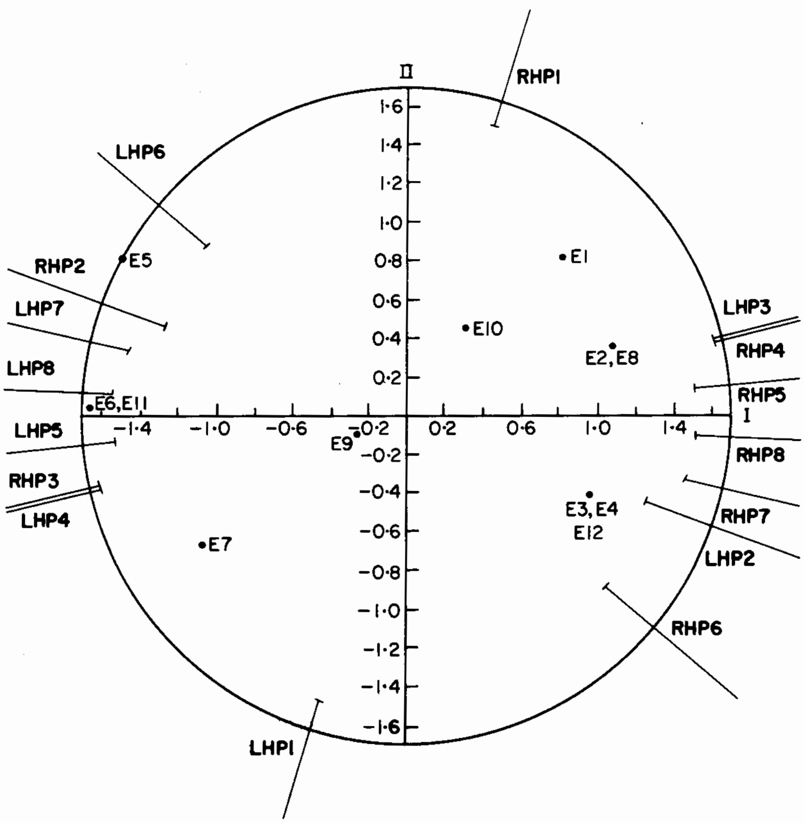

FIG. 2. Principal components analysis of Jane's grid by INGRID.

left-hand pole of construct 6 is associated more loosely with this but both poles of construct 1 are isolated well away from the cluster. There is a mirror image cluster of the right-hand poles of constructs 4, 5, 6, 7 and 8, together with the left-hand poles of constructs 2 and 3. Because the assignment of elements to poles is such that the vector of assignments to the left-hand pole is the reverse of that to the right-hand pole such a mirror image is bound to occur with conventionally elicited grids.

Atkin's (1974) *Q-Analysis* provides an alternative means of analysing the structure behind a matrix of data such as that of Fig. 1. In terms of the present discussion it is convenient to regard it as a form of hierarchical cluster analysis based on a distance-measure, although it is conventionally presented in combinatorial topology terms. The data of Fig. 1 was analysed using a program QARMS (*Q-A*nalysis of *R*elations in *M*ultilevel *S*tructures) that can also deal with grids using rating scales as well as the binary data shown. The results are shown in Fig. 3 with the connectivities also drawn out as a hierarchical cluster.

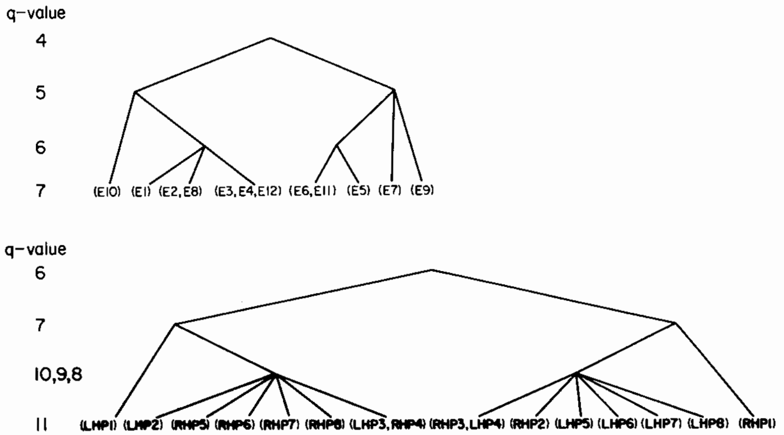

FIG. 3. Q-Analysis of Jane's grid by QARMS.

Shaw's (1980) FOCUS algorithm is another distance-based grid analysis technique that sorts the constructs into a linear order such that constructs closest together in the space are also closest together in the order. It has the advantage in presentation that the sorting is used only to represent the original grid reorganized by the "neighbourness" of constructs and elements. It is up to the user to construe meaning into the result and confirm this directly in terms of the original data. Figure 4 shows the grid of Fig. 1 as processed by FOCUS. Note that the letters "X" and "O" have been replaced by the numerals "1" and "2", respectively, as the normal FOCUS convention, rather than the "1" and "0" used above. In reorganizing the grid FOCUS has also reversed constructs 2 and 3. Concentrating on the construct analysis again, it can be seen that constructs 3 and 4 are equivalent and close neighbours of 5, 7 and 8, and that this cluster is itself a close neighbour of the cluster formed by 2 and 6. Construct 1 is not linked into the other constructs at a meaningful level.

Thus, for this example at least, the actual clusters produced by FOCUS, QARMS and INGRID do not differ in any meaningful way. In general, since all these techniques use

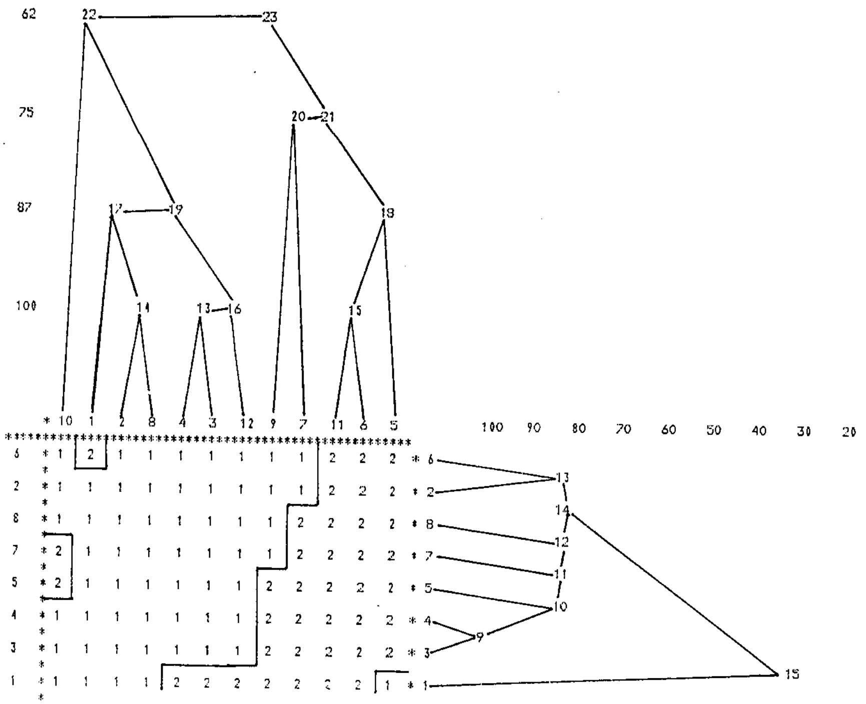

FIG. 4. Cluster analysis of Jane's grid by FOCUS.

distance measures to produce clustered data, one would expect the results to be similar. The objective of FOCUS is not to produce a different analysis in terms of clusters but rather to present the analysis in terms of the data that produced it. In this way those who produced the grid are able to see how the decisions they made in doing this affect the actual analysis.

The *reversal* performed by FOCUS is an important operation in analysing a repertory grid. Kelly (1955, p. 283) uses such a process of reversal (which he calls "reflection") in his analysis of repertory grids, and the need for it clearly arises from the artificiality of the assignment of "left-hand" and "right-hand" poles to a construct. Unless some special additional rationale is in operation, what are called the left-hand and right-hand poles of a construct may be reversed without distorting the grid providing the assignments of elements to those poles is also reversed. In principal components analysis and Q-Analysis such reversals show up in the clustering of left-hand poles together with right-hand poles, for example as in Figs 2 and 3.

It is convenient to make a point here that applies to all techniques for grid analysis. Any relation we infer between constructs from a given grid are derived from the set of elements used in eliciting that grid. Hence they should be qualified by a reference to that set: not "constructs 3 and 4 are equivalent", but rather "in relation to elements 1 through 12, constructs 3 and 4 are equivalent". To the extent that we drop this qualification we are proceeding inductively rather than deductively and our conclusions may be incorrect. This applies to any conclusion that extends the relation between constructs to elements that have not been tested, for example "in relation to your close acquaintances, constructs 3 and 4 are equivalent". The significance of such inductive steps in the conversational elicitation of constructs will be discussed in section 13.

In conclusion the various distance-based analyses of grids each provide related methods of clustering elements and constructs in such a way that one can provide feedback on possible *structures* underlying the construing. They have two factors in common that restrict their application in some contexts. Firstly, the structure exhibited is limited in its semantics to a symmetric relation of "neighbourness" between the items clustered. Secondly, the analyses produce results about distances, components, connections, geometrical relationships, and so on, which represent a different way of looking at the data. This may be valuable in itself and may be expressed through basic notions of *similarity*. However, for some applications such as interactive discussion in conversational grid elicitation it would be preferable to have an analysis that expresses relations in the data in terms more immediately meaningful and directly related to the data itself. It was these considerations that led us to the logical data analysis described in the next section.

4. Logical grid analysis

There is an alternative way of looking at the grid of Fig. 1 which views it not as a set of vectors in a space but instead as an assignment of *truth-values* to *logical predicates*. We may take the left-hand pole of each construct in Fig. 1 to be a logical predicate that may be applied to a person and take the assignment of the value to a particular element in the grid to mean that the predicate is *true* for that element. Conversely we may take the value of 0 assigned to an element for a construct to mean that the predicate represented by the left-hand pole of that construct is *false* for that element. It is convenient to use the abbreviation **LHPm** for the predicate that corresponds to the left-hand pole of construct *m*. Thus **LHP5** is the predicate for the left-hand pole of construct 5. If we then also adopt the convention that E*n* stands for the *n*th element then the notation **LHPm** E*n* may be used to denote the truth value of the predicate corresponding to the left-hand pole of construct *m* when applied to the logical constant corresponding to the *n*th element. A repertory grid, such as that of Fig. 1, is then the matrix of such truth values for the *m* constructs and *n* elements involved.

Because of the inverse relation already noted between assignments to the opposite poles of a construct in a conventional repertory grid, the predicate corresponding to the right-hand pole is logically related to that corresponding to the left-hand pole. We normally require that an element be assigned to one, and only one pole, so that if **LHP** E is true then **RHP** E must be false, and vice versa. Hence, **LHP** E is essentially the *logical negation* of **RHP** E. For the current discussion we shall accept that this relation exists as a constraint between the two predicates corresponding to the two poles. However, it is not an essential one for the theory and we discuss in section 11 the possibility of relaxing it and the consequences of doing so. For this reason we shall carry out most of the discussion in terms of the left-hand poles and associated predicates primarily, noting occasionally the corresponding phenomena for right-hand poles.

The logical analysis of construct systems in repertory grid form proposed here seems completely new. However, it is interesting to note that Slater (1977) has a section on

"Connections between personal construct theory, logic and probability theory". In this he states that (Slater, 1977, p. 34):

> The typical proposition in personal construct theory, *E may be construed as C*, paraphrases the typical proposition of Aristotelian logic, *S is P*, i.e. subject is predicate. It is difficult to conceive of any proposition that can be stated in one of these forms and not the other.

Thus, the point is made that it is possible to conceive of the assignment of an element to the pole of a construct as being similar to the assignment of the truth value *true* to the predicate applying to that element, but it is not developed. The rest of the book referenced develops the numerical, principal components approach to grid analysis. In this section we show that a purely logical analysis may also be developed.

First let us examine the previous relation of equivalence between constructs in logical terms. We can define two logical propositions to be equal if their truth-values are the same, and this also corresponds to their numerical truth-values being equal, e.g.

$$\mathbf{LHPm}\,\mathrm{E} = \mathbf{LHPn}\,\mathrm{E}. \tag{1}$$

We can define two logical propositions involving the same free variable as being equivalent if they are equal for all values of that free variable, e.g.

$$\forall \mathrm{E} \quad \mathbf{LHPm}\,\mathrm{E} = \mathbf{LHPn}\,\mathrm{E}, \tag{2}$$

and it is then convenient to drop the variable and write

$$\mathbf{LHPm} \equiv \mathbf{LHPn}. \tag{3}$$

Now this equivalence between the poles of constructs clearly coincides with our previously discussed equivalence in terms of distance. If two propositions are logically equivalent in this way then the vectors of truth-values against elements are the same and hence they are zero distance apart. The converse may also be shown for any proper distance measures.

However, in terms of logical relations equality is only one of many possible relations. There are six binary logical operators between propositions that establish relations between them. Two of these relations are symmetrical and correspond to the two propositions being equal, or to one being equal to the negation of the other. This corresponds to the reversal or reflection of constructs discussed above. The other four operators are forms of *implication* between propositions, that one proposition being true implies that the other is also true. The four forms arise because of the possibilities of negation, that one being true implies the other is not, and so on. They may all be derived from the one operator, $\supset$, where

$$\mathbf{LHPm}\,\mathrm{E} \supset \mathbf{LHPn}\,\mathrm{E} \tag{4}$$

means that the assignment of element E to the left-hand pole of construct *m* implies that it is also assigned to the left-hand pole of construct *n*.

In constrast to the equality relation, the implication relation is asymmetric. If we assert the implication given in (4) then we are only constraining the truth-value of **LHPn** E if **LHPm** E is true. If this is not so, and element E is not assigned to the left-hand pole of construct *m*, then we are saying nothing about its assignment to the left-hand pole of construct *n*. This constrasts to the equality relation asserted in (1) where the proposition **LHPm** E being false also leads to **LHPn** E being false in order to satisfy the equality.

One important property of the implication relation is its transitivity. From the way in which we have defined it we can see that if, as well as (4), we have

$$\mathbf{LHPn}\,\mathrm{E} \supset \mathbf{LHPo}\,\mathrm{E}, \tag{5}$$

then we can derive

$$\mathbf{LHPm}\,\mathrm{E} \supset \mathbf{LHPo}\,\mathrm{E}. \tag{6}$$

This is the normal transitivity of an implication relation in a logical calculus.

Asserting mutual implication between two propositions allows us to derive their equality. Thus adding the converse asymmetric assertion

$$\mathbf{LHPn}\,\mathrm{E} \supset \mathbf{LHPm}\,\mathrm{E} \tag{7}$$

to that of (4) does enable us to derive (1). From this we can see that the relation of implication is a weaker one than that of equality but closely related to it in that if we know the four implication relations between two propositions we may infer the two equivalence relations between them. These results from elementary propositional logic show that it is of interest to consider the implication relation in repertory grid analysis since the equality and equivalence relations normally analysed may be derived from it but not vice versa.

In the same way that we moved from the relation of equality between individual propositions in (1) to that of universal equivalence between them in (2), we may say that one proposition involving a free variable *entails* another proposition involving the same variable if it has an implication relation with it for all values of the free variable, e.g.

$$\forall \mathrm{E} \quad \mathbf{LHPm}\,\mathrm{E} \supset \mathbf{LHPn}\,\mathrm{E}, \tag{8}$$

and it is then convenient to drop the variable and write

$$\mathbf{LHPm} \rightarrow \mathbf{LHPn}. \tag{9}$$

We will read this as "the left-hand pole of construct m entails the left-hand pole of construct n". Clearly entailment, being derived from implication, is also asymmetric, and mutual entailment gives us equivalence in the same way as mutual implication gives us equality. Thus adding the converse entailment to (9):

$$\mathbf{LHPn} \rightarrow \mathbf{LHPm} \tag{10}$$

to (9) itself allows us to derive the equivalence of (3). Note similarly that the entailment relation is transitive like the implication relation so that from (9) and

$$\mathbf{LHPn} \rightarrow \mathbf{LHPo} \tag{11}$$

we may derive

$$\mathbf{LHPm} \rightarrow \mathbf{LHPo}. \tag{12}$$

We have linked the discussion of this section to personal construct theory. However we note that most of our definitions come directly from classical logic and are independent of personal construct theory. The formal mechanisms for defining entailment are rather more complex than those used here because the logic of entailment is concerned to avoid certain paradoxical results (Anderson & Belnap, 1975). The nature of these paradoxes does have some interest in personal construct theory because they are to do with *relevance* in entailment—does one proposition entail another in a relevant way or just through an artefact of the logical calculus? Similar but deeper questions arise when we consider the derivation of entailment from repertory grid data—is one construct relevant to another in the way in which it entails it or is the derived relation a fortuitous one? We consider such questions in sections 7 and 13.

It is also worth noting that our definitions of equivalence and entailment are also related to those in *modal* logics (Snyder, 1971). We can regard (2) and (8) as being definitions of *necessary* equality and *necessary* implication in a quantification model of a modal logic. In the context of personal constructs we can see this best by noting that two verbal interpretations of (8) are acceptable: "when you assign an element to the left-hand pole of construct *m* you *always* also assign it to the left-hand pole of construct *n*", or "when you assign an element to the left-hand pole of construct *m* you *necessarily* assign it to the left-hand pole of construct *n*". These links may be formalized through a *possible worlds* (Bradley & Swartz, 1979) model of modal expressions by noting that each element provides a possible world for construing. Entailments according to our definition then become logical implications that are true for all possible worlds currently under consideration. This is a useful and evocative viewpoint because it links personal construct theory with the linguistic semantics of counterfactuals and presuppositions (Lewis, 1973) which is very relevant to Kelly's concept of constructs being "used for predictions of things to come". It also provides useful technical links into the formal mechanisms for treating the topological structure (Lemmon, 1966) of possible worlds and its role in logic and semantics which seem equally applicable to personal construct theory.

To conclude the rather abstract discussion of this section and lead into the more concrete operational implementation of the next it is worth considering a specific example of what we mean by entailment, its asymmetry, and the derivation of equivalence from entailment but not vice versa. The poles of two constructs may be quite distinct in terms of equivalence yet closely related in terms of entailment. For example suppose that in construing people someone uses the two constructs *m*: *runs–doesn't run* and *n*: *energetic–passive*, then we might well expect to find that **LHPm** entails **LHPn** but that **LHPn** does not entail **LHPm**, that it is that being a *runner* entails being *energetic* but being *energetic* does not entail being a *runner*. If we analyse such a construct structure in terms of distance measures and hence of equivalence only then we shall not derive such asymmetrical relations between constructs even though they are meaningful and of practical interest.

5. ENTAIL: a program to derive entailments between constructs

It is simple to derive the entailment structure between the poles of constructs. We only have to check the truth of the four possible implications for all elements. Thus **LHPm** entails **LHPn** is checked by noting whether whenever an element is assigned to the left-hand pole of *m* it is also assigned to the left-hand pole of *n*. If so, then the entailment relation holds true, otherwise it is false. Clearly, as we noted above, it would also suffice to check that whenever an element is not assigned to the left-hand pole of *n* it is also not assigned to the left-hand pole *m*. We call the program that performs this analysis ENTAIL (*E*ntailment *N*ets *T*hrough *A*nalysing *I*mplicational *L*inks). Note again that the inference from a particular set of elements that one pole of construct *m* entails one pole of construct *n* is an inductive one if we assume that it applies to other elements in addition to those used in its derivation.

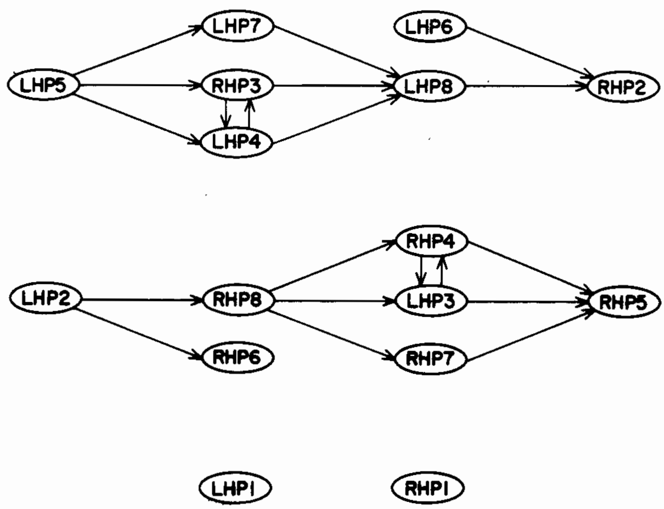

FIG. 5. Entailment analysis of Jane's constructs by ENTAIL.

Figure 5 shows the entailments between the poles of constructs derived by ENTAIL from the grid of Fig. 1; they are drawn out as a direct graph. There are effectively two main sub-graphs which are mirror images of one another plus two isolated poles. One of the sub-graphs shows the entailments for one set of poles, and the other the entailments for the opposite poles. Note that the "reversal" of constructs 2 and 3 apparent in the INGRID, QARMS and FOCUS analyses shows up as **LHP2** and **LHP3** appearing in the graph of the right-hand poles of the other constructs and vice versa. Because of the essential bipolarity assumed in the elicitation of the grid the two graphs are essentially the same with the arrows and poles reversed in one relative to the other. In section 11 we discuss extensions to the form of grids which would result in such pairs of graphs not necessarily having such a simple relation.

Note that we have taken advantage of the transitivity of the entailment relation not to draw in all the arrows strictly necessary. Thus we have not drawn an arrow from **LHP2** to **RHP7**, **RHP5**, **RHP4**, and **LHP3** because there is an arrow from **LHP2** to **RHP8** and then one from **RHP8** to **RHP7**, **RHP7** to **RHP5**, and so on. We can see from the figure that **LHP2** entails **RHP8**, **RHP7**, **RHP5**, **RHP4** and **LHP3** by tracing through the graph. Note that the equivalence between **LHP3** and **RHP4** now shows up as mutual entailment.

It is very interesting to compare Fig. 5 with the results of the INGRID clustering in Fig. 2, the QARMS clustering in Fig. 3 and the FOCUS clustering in Fig. 4. We can see that the same hierarchy of clusters has turned up: (3, 4); ((3, 4), 5, 7, 8); (2, 6); (((3, 4), 5, 7, 8), (2, 6)); with construct 1 unrelated to the others in all cases. Thus the ENTAIL analysis gives rise to the same basic clustering as did INGRID, QARMS and

FOCUS. At a more fundamental technical level we would expect all such distance-based clustering techniques to show such similarity with non-pathological data. Both the fundamental and empirical similarities are important in their own right since two of these programs are widely used for grid analysis and one would hope that any new technique would continue to provide at least the same basic analysis.

However, there is additional information in Fig. 5 that goes beyond that available in Figs 2, 3 and 4. This comes from the directed nature of the entailment links shown.

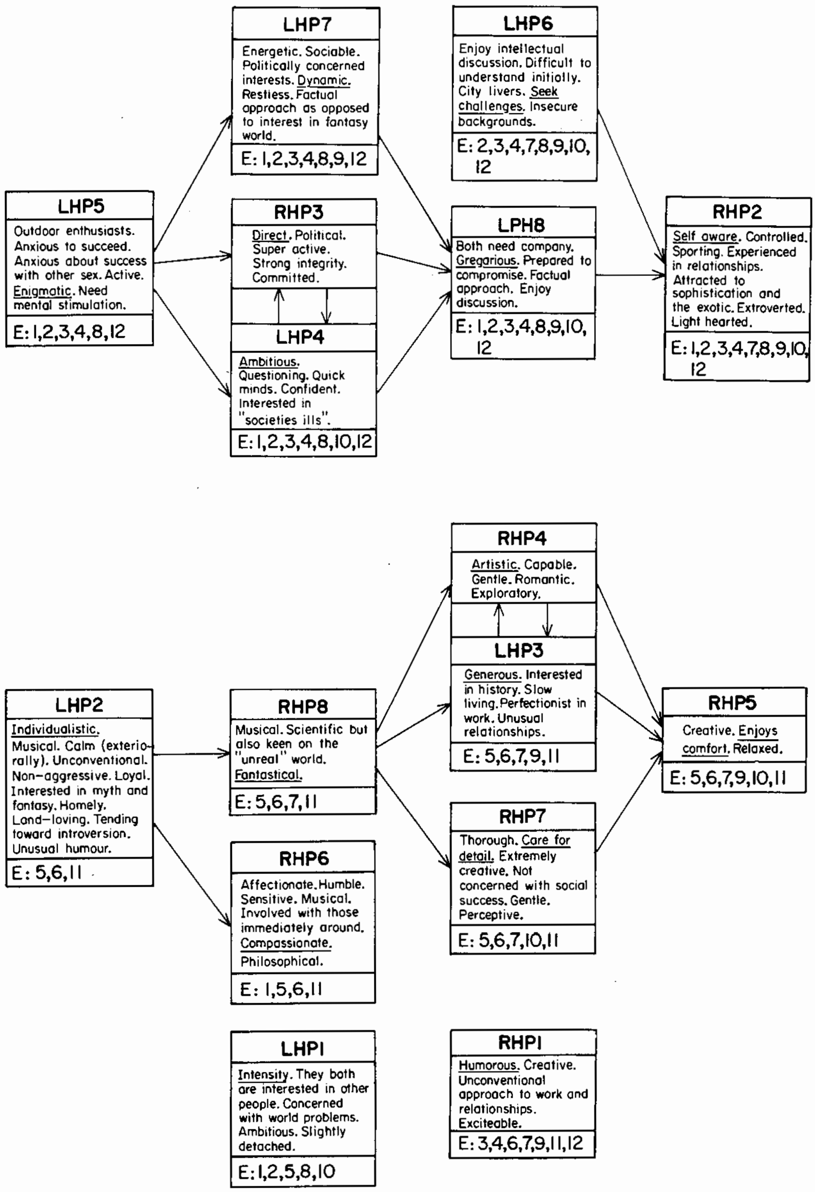

FIG. 6. Entailment analysis of Jane's grid by ENTAIL.

There is equivalence only between **LHP3** and **RHP4**—all the other relations are one way only. To show the significance of this we have drawn out Fig. 6 which gives the full text attached by Jane to each pole of the construct together with the elements assigned to that pole. The assymetry of the entailment relation may be seen by considering that from **RHP4** to **RHP5** for example. We see from the descriptions of the poles that Jane is saying that any one of her acquaintances who is *artistic* and so on is also *creative* and so on. However, the converse does not hold.

From the element data in Fig. 6 we can see the reason for this asymmetry. For example, from the elements assigned to **RHP4** and **RHP5** we can see that the entailment between them not being mutual is due to Jane's acquaintance element 10 being termed *creative* but not *artistic.* In this case only one element breaks down the equivalence. If we consider the entailment from **LHP8** to **LHP5**, that her acquaintances who are *musical* are also *artistic* then the converse is not true of two acquaintances, elements 9 and 10. And if we consider the entailment from **LHP2** to **RHP5**, that being *individualistic* entails being *creative* then the converse is not true for elements 7, 9 and 10. Thus the construct analysis produced by ENTAIL has reproduced the clusters shown by INGRID, QARMS and FOCUS but it has also shown up new features of the data not evident in these distance-based and essentially symmetric forms of analysis.

Note finally that the form of analysis produced by ENTAIL has some of the features of INGRID in that it is two-dimensional and some of the features of QARMS in that it provides hierarchic clusters. However, it also retains the key feature of FOCUS in that it represents the original data in a reorganized form. Like both INGRID and FOCUS it also shows the relation between elements and constructs, but unlike them it extends this relation to show the asymmetrical, directed entailment structure between constructs.

6. Strength of entailment

The program ENTAIL described in section 5 produces a list of entailments between constructs. The status of these entailments is best seen by noting that the question asked in putting an entailment on the list is effectively "does any assignment of elements to the poles of constructs show that this entailment does not hold"? If the answer to this question is "yes" then the entailment is not listed. Thus each entailment listed is *consistent* with the grid. We shall consider in section 13 the question of ascertaining whether the entailments listed are in some sense real determinants of the results or just artefacts. In this section we look at the other side of this question as to the significance of not listing entailments.

When we evaluate a graph of entailments such as that shown in Fig. 5, we are noting not only the arrows which are present but also those which are absent. There is an entailment from **LHP5** to **LHP4** but not one from **LHP4** to **LHP5**. Therefore **LHP4** is not equivalent to **LHP5**. There is an asymmetric relation between the two predicates which may be due to a variety of interesting phenomena (such as superordination—section 7). We are beginning to *interpret* the grid through the analysis produced by ENTAIL. However, how sure are we that entailments not shown are actually missing? How "near" to being equivalent are the two predicates? Section 13 examines one approach to answering such questions through interaction with the person from whom the grid was elicited. In this section we consider only the mathematical analysis of the actual grid data.

One possible approach to the "strength" of entailment is to relate it to *conditional probability* measures. We note that if, and only if, the entailment relation of (9) holds, then the conditional probability of **LHMn** being true for an element given that **LHPm** is true is 1, i.e.

$$p(\mathbf{LHPn}|\mathbf{LHPm}) = 1. \tag{13}$$

Hence it is natural to take this probability measure as one also of the strength of entailment. However, it has the defect of not dropping to zero when no relation holds between the two predicates. Indeed if **LHPn** and **LHPM** are independent of one another we have

$$p(\mathbf{LHPn}|\mathbf{LHPm}) = p(\mathbf{LHPn}), \tag{14}$$

so that a more descriptive measure of entailment can be obtained by subtracting this value and renormalizing to unity for the case of entailment:

$$m(\mathbf{LHPm} \to \mathbf{LHPn}) = (p(\mathbf{LHPn}|\mathbf{LHPm}) - p(\mathbf{LHPn}))/(1 - p(\mathbf{LHPn})). \tag{15}$$

This takes the value: 1 if **LHPm** entails **LHPn**; 0 if the two predicates are independent; and negative or intermediate values otherwise.

Such a measure is useful in giving more detail to the entailment analysis. However it does not satisfy our criterion of providing an analysis interpretable at the same level as the data—the measure itself introduces a new construction which will not be inherently meaningful to the person who generated the grid. An alternative approach to the grading of entailment was given in Shaw & Gaines (1980) which introduced the predicate *usually* in the analysis performed by ENTAIL. This predicate is a quantifier similar in nature to the "for all" used in defining entailment in (8), but qualified to allow for some disconfirming instances so that it may be read as "for all but N cases" where N is some small number, such as 1 or 2.

Such a quantifier allows a natural grading of entailment in terms that are immediately meaningful to the originator of the grid: "when you say someone runs you always also say they are energetic and when you say someone runs you usually also say they are energetic". Use of the quantifier *usually* to give a graded analysis gives a structure similar to the connectivity levels coming from Atkin's (1974) Q-Analysis. It is also readily extended to the multilevel case where rating scales rather than binary assignments are used in eliciting a grid (see section 9).

ENTAIL has facilities for calculating entailments under the quantifier *usually*. If we apply it to Jane's grid, then it condenses the construct structures shown in Fig. 5 into just: an equivalence between **LHP2**, **LHP3**, **RHP4**, **RHP5**, **RHP6**, **RHP7** and **RHP8**; a similar equivalence between the opposite poles to these; **LHP1**; and **RHP1**. With more complex grids, however, we have found the use of graded entailment through such a predicate an important feature of the analysis.

7. Entailment and the superordination/subordination hierarchy

The directed graph of entailment is reminiscent of the type of structure that we get when considering Kelly's concepts of "superordination" and "subordination" between constructs. He notes that there is a natural hierarchy amongst constructs (Kelly, 1955, p. 479):

> Constructs are construed by means of other constructs, and those, in turn, by still other constructs. It is thus a system is formed.

Entailment as defined here appears to treat constructs at the same level and yet to derive a hierarchical structure amongst them. We can see that this structure may have some relationship to Kelly's "system" through the example given previously: *runs* entails *energetic* but not vice versa because running is an energetic activity. Thus *energetic* is superordinate to *runs*. In logical terms we would normally expect predicates applicable to different categories to have different names and note that the predicate *energetic* applied to an activity is different from the predicate *energetic* applied to a person. In everyday language, however, ellipsis of various sorts is common and such distinctions are dropped, or implicit. The rationale seems to be that someone who undertakes an energetic activity will themselves be termed energetic.

We can formalize this argument by considering two constructs m and n such that n is superordinate to m and such that **LHPm** is construed as being assigned to **LHPn**. If we now assume that ellipsis occurs in statements such that any element assigned to **LHPm** of the subordinate construct is also stated to be assigned to **LHPn** of the superordinate construct, then we have the entailment

$$\mathbf{LHPm} \rightarrow \mathbf{LHPn}. \tag{16}$$

However, we do not have the converse entailment since it is possible for an element to be construed as assigned to **LHPn** without its being assigned to **LHPm**. This might happen, for example, through it being assigned to **LHPo** of an alternative subordinate construct o of construct n.

Thus we can see that the subordination/superordination hierarchical system defined by Kelly will show up as an entailment structure between the poles of constructs. However, can an entailment itself always be construed as arising from superordination/subordination? Again a simple model of some natural language phenomena suggests that the answer is yes. Korzybski (1933) has noted the wide ranging effects of the common phenomenon in natural language whereby we treat class-names as if they were those of individuals. If we have an entailment of the form of (16) then we may express this as **LHPm** "leads to" **LHPn**, meaning that any element assigned to **LHPm** is also assigned to **LHPn**. We may then through ellipsis treat **LHPm** itself as representing the class of elements assigned to it and hence itself being construed as an "element" assigned to **LHPn**. There then exists a relation between the constructs on Kelly's definition whereby m is subordinate to n and n is superordinate to m.

This relation between entailment and the subordination/superordination hierarchy raises many other questions: how does it relate to other approaches to eliciting the hierarchy such as Hinkle's (1965) "laddering" and Glanville's (1980) "circle of derivations"; how can we speak of a hierarchy of constructs when the converse entailment applies to the right-hand poles; does it throw light on the criticisms of the whole concept of a superordination/subordination hierarchy?

Firstly, the question of the relationship between implicitly derived structures in human rationality and explicitly verbalized ones is complex. Laddering derives the construct hierarchy directly by asking "why" questions to go up it and "how" questions to go down it: Q: why do you run? A: to be energetic; Q: how are you energetic? A: through running. We can infer from the first that running entails being energetic, and from the second being energetic is entailed by running. Thus, from a logical point of view the indirect elicitation of implicit entailments through ENTAIL and the direct elicitation of the construct hierarchy through laddering should correspond. There are two reasons in practice why this may not occur: that laddering tends to bring in additional constructs in that it is not only a structural analysis but also a different form of elicitation; and, more fundamentally, that the logical correspondence does not necessarily imply a psychological one—people's verbal expressions of the rationale behind their behaviour can be quite dissociated from their actual behaviour.

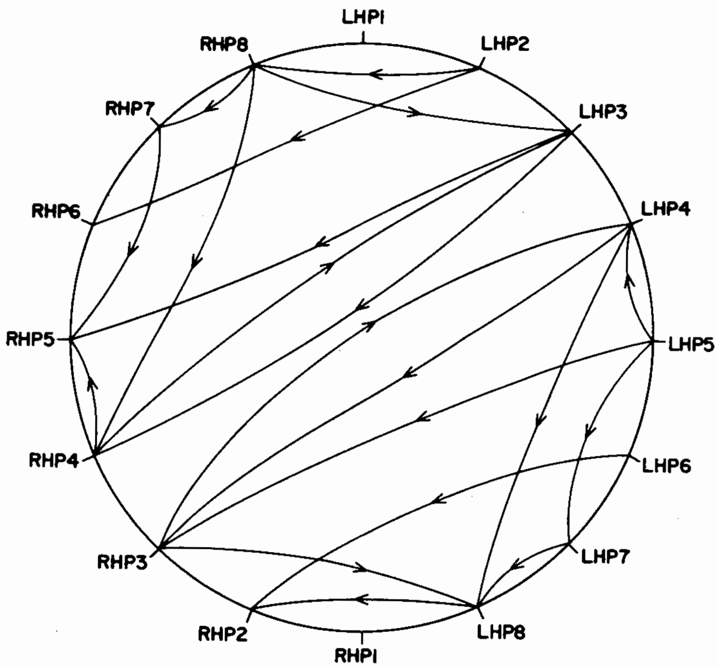

FIG. 7. Circle of derivations representation of ENTAIL analysis of Jane's constructs.

Figure 7 shows the "circle of derivations" corresponding to Fig. 5. This is what would be obtained directly from Jane using Glanville's technique if she agreed totally with the entailments derived by ENTAIL. It would be interesting in future studies to use both Hinkle's and Glanville's methods to obtain directly entailment structures and compare them with those from ENTAIL. Any irresolvable disagreements between the directly derived and the indirectly derived structures would be evidence of dissociation between verbal and actual behaviour. This dissociation can be very significant in attempts to extract from a person information about their skilled behaviour (Bainbridge, 1979). Examples occur in the literature on *expert systems* (Michie, 1979) which throw light on the difference between modelling the actual behaviour of people and accepting their own verbal models. Michalski & Chilausky (1980) have reported some interesting comparative results on a system for acquiring knowledge from experts on plant disease diagnosis where rules induced from the decision-making behaviour of an expert were far superior to those which the expert actually stated he was following.

The possibility of such dissociation between verbal and actual rationality does not affect just the relation between construct structures derived through ENTAIL and those derived through laddering. It is a general phenomenon whereby psychological and logical models of human rationality differ. For example, we might have someone who agrees that **LHPm** entails **LHPn** and also that **LHPn** entails **LHPm**, but does not agree that **LHPm** and **LHPn** are equivalent. Wason & Johnson-Laird (1972) have demonstrated that such pathology in the reasoning process is common in many human cognitive activities. Clearly there are many ways of resolving such conflicts. We can go back to the definitions of the terms, agree them and then point out the discrepancy, either in the general case or relative to the particular data. Such a "socratic" approach through explanation and example seems a natural extension of the interactive grid elicitation program PEGASUS (Shaw, 1980) that is often used in conjunction with FOCUS, and this is discussed in section 13. In concluding the discussion here we note that it is dangerous to assume that even basic logical relationships and results derived from them will always be obvious, or even accepted without debate, by people using personal construct structure analysis programs.

Our second question is on the direction of the construct hierarchy. We have already noted that in the conventional elicitation of constructs the entailment between two left-hand poles is inherently associated with a reverse entailment between the corresponding right-hand poles. Thus from (16) we can infer

$$\mathbf{RHPn} \rightarrow \mathbf{RHPm}. \tag{17}$$

This association is often a natural one but there seem to us no logical grounds why it should be a necessary one and in section 11 we discuss an extension of conventional grid methodology which avoids the direct derivability of (17) from (16). However, regardless of this, there will still be a tendency for the left-hand and right-hand poles of a construct to be at opposite ends of the order relation derived by ENTAIL. This might seem to imply that any particular construct may be at either end of the hierarchy according to which pole one considers, and this then conflicts with Kelly's definition of the hierarchy in terms of generality.

This problem can be resolved in major part by noting that the inverse relation exemplified by (16) and (17) causes the entailment graph for the poles to split into two subgraphs that are duals of each other. Figure 5 illustrates this for the particular example analysed. Either subgraph gives rise to the same construct hierarchy but with the arrows reversed. Whether the direction of the arrows indicates increasing subordination or increasing superordination is often obvious by inspection in looking at the relative generality of the two extremes. Thus the entailment hierarchy can be used to derive the structure of the subordination/superordination hierarchy but its direction needs to be determined by other considerations.

The example of Jane's grid used as an illustration is exceptionally simple and in general more complex and fragmentary structures may be found. For example, the isolation of construct 1 in Fig. 5 illustrates that there is no necessity for all the constructs to fit into the same hierarchy. Each of the dual subgraphs may fragment into subgraphs and then one may have several different systems of subordination/superordination. Also, as noted above, there is no reason for the entailments to be necessarily construed as a subordination/superordination hierarchy. This is only one way in which entailment can arise and provides one possible rationale for explaining the entailments.

It is probable that the discussion of this section and particularly these final notes throw light on our third question about criticism of the whole concept of a subordination/superordination hierarchy. Slater presents a number of argments that lead him to the conclusion that "the theory that construct systems are hierarchical appears questionable to some extent" (Slater, 1976, p. 45). In particular he quotes Kelly to the effect that "the ordinal relationship between constructs may reverse itself from time to time" (Kelly, 1955). If our discussion here relating entailment through linguistic ellipsis to subordination/superordination provides a model of the actual processes at work then they may be expected to be variable and subject to change. Constructs themselves are conventional and so are the entailments between them and hence so is the structure of the construct system. If our construct systems are used to guide our actions then as our goals change it may well be that the structure of our construct system itself changes. What is a "cause" in one context may become an "effect" in another.

Thus, viewing the basic ordinal structure of constructs as being one of logical entailment between poles does enable one to subsume other such structures and provide a basis for understanding their operation and dynamics.

8. Asymmetric element analysis

The logical analysis of construct structures through the asymmetrical implication relation makes sense both formally and intuitively. Is there a comparable analysis for the elements? At first sight the answer may appear to be negative. One element "entailing" another is not necessarily a natural concept, whereas one element being "near" another in construct space is much more so. We can interpret such "nearness" as *similitude* and have a natural interpretation of the two elements being similar. However, there are two factors which should be taken into account in analysing the element structure.

Firstly, if we look at the relation between elements in terms of a distance structure based on the vectors of values of elements on constructs then the *weighting* assigned to each construct dimension is very significant in determining the element clusters. This weighting determines the relative significance that we attach to dissimilarities between elements in relation to differing constructs. If we apply a uniform weighting then we are effectively assuming that each construct is equally important in determining the grouping of elements. This clearly depends on how the grid was elicited and the purpose of doing the grouping.

Secondly, if we look at an asymmetric implication relation between elements we are again making assumptions about constructs and their significance. The type of relation will be

$$\forall\mathbf{LHP} \quad \mathbf{LHP}\,\mathrm{E}m \supset \mathbf{LHP}\,\mathrm{E}n, \tag{18}$$

which we can abbreviate conveniently to

$$\mathrm{E}m \rightarrow \mathrm{E}n. \tag{19}$$

The quantification is now over the predicates so that what we are considering is not expressible in the first-order predicate calculus. The meaning of the expression is dependent on some assumptions about the coherence of the class of predicates over which quantification occurs.

One possible source of coherence amongst constructs is that they have a *preferred* pole and we might then interpret the "for all" in (19) as "for all the preferred poles". The arrow in (19) then defines a *preference order* on elements since E$m \rightarrow$ En then means precisely that "En is construed as preferred on at least every construct where Em is preferred". If we use ENTAIL to analyse Jane's grid of Fig. 1 for the preference relation between elements assuming for the purposes of this example that the preferred poles are the left-hand ones except for constructs 2 and 3, then we obtain the preference graph between elements shown in Fig. 8. The close resemblance of this in terms of clustering between elements to the INGRID (Fig. 2), QARMS (Fig. 3) and FOCUS (Fig. 4) analyses will be noted. However, Fig. 8 also contains additional information since it gives a direction of preference.

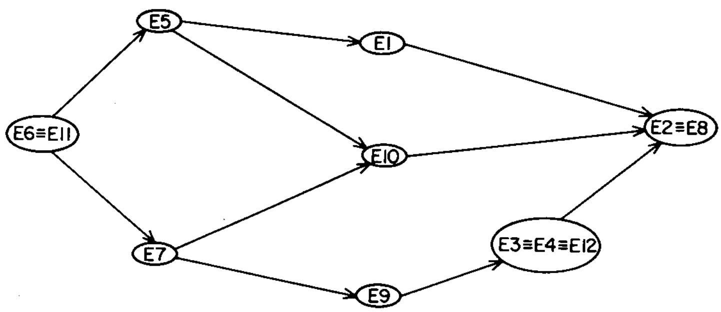

FIG. 8. Preferences analysis of Jane's elements by ENTAIL.

Thus the logical approach to grid analysis also leads to a comparable element analysis to other approaches. It can also provide additional information about asymmetric relations between elements when an appropriate interpretation such as a preference relation over constructs exists.

9. Extending entailment to rating scales—fuzzy semantics

So far in this paper we have analysed grids with binary assignments of elements to poles using a classical logic with two truth values. In this section we show how the logical analysis extends to the *multivalued logics* (Rescher, 1969) with which one can analyse grids based on rating scales. Kelly (1955) presented constructs as binary categories and based his own methodology for eliciting constructs on this. However, other workers found the need for "shades of grey" between the two poles of a construct and in a later work Kelly (1970, pp. 13–14) notes that this is consistent with his notion of a construct:

> The construct, of itself, is the kind of contrast one perceives . . . while constructs do not represent or symbolize events, they do enable us to cope with events, which is a statement of a quite different order . . . . They also enable us to put events into arrays or scales, if we wish.

It is common in many practical applications of repertory grids to use an N-point scale with 1 being an assignment to the left-hand pole and N being an assignment to the right-hand pole, and intermediate numbers representing some form of "intermediate" assignment. N is usually odd, 5 or 7, to allow a "neutral" mid-point to the scale.

The semantics of such rating scales presents a number of problems in its own right. Kelly's original binary assignments may be interpreted as the truth or falsity of predicates. Intermediate points on a rating scale are not so readily, or uniquely, interpretable. For example, the "neutral" point 3 on a 1 to 5 scale say may be interpreted as "this element lies half way between the poles", or as "this element should be assigned to both poles", or as "neither pole is appliable to this element", or "sometimes this element comes under one pole and sometimes another", or "I am not sure what pole to put this under", or "I do not wish to construe this element in this way", and so on. In logical terms we are attempting to use a single truth value to encompass many different modalities (White, 1975).

The extension of binary distinctions to multi-valued ones may be treated at a fundamental level. We have already noted in section 2 the close relation of Kelly's constructive alternativism to Spencer Brown's "calculus of distinctions". Varela (1979) has shown how Brown's calculus may be extended to the multi-valued case. Within a basic bipolar distinction may be interpolated others through logical operations that correspond to expressions that generate paradoxes of *self-reference* in classical logic. Varela (1975) shows that an essentially three-valued logical calculus arises from the use of a single self-referential form in Brown's calculus of distinctions. Gaines (1976) shows how such "primitive paradoxes" may be iterated to give an indefinite number of distinctions between the poles of the distinction originally made, and hence how the truth value of an arbitrary proposition may be approximated to any accuracy on a continuous scale through a Dedekind section.

This move from a binary basis for making distinctions to a multivalued one raises problems of a semantic nature even at a fundamental level, particularly those of interpreting intermediate "truth-values" (Haack, 1979). However, the need for rating scales in practice, and an appropriate underlying theory, does seem an essential one in terms of the human construct systems and their logic. In the physical sciences the expected and preferred source system in which to represent data is quantitative. We use a source system of physical quantities and their precise measurement. However, the underlying constructs of physics have been derived and refined over a very long period and are themselves of a peculiar, and perhaps unique, nature. The existence of continuous and limitless scales for physical variables of length, time, mass, charge and so on, is an important phenomenon that marks out the constructs involved as being different from those in many other sciences.

The existence of refined measuring schemes for some constructs should not blind us to their close relationships to other constructs for which no such physical measurement exists, for example, the concepts of "tallness" and "beauty" (Gaines, 1976). The concept, the perception, of "tallness" exists in a more primitive sense than does the measurement of "height". We are able to generate and follow arguments involving "tallness" without having any concept of inches, centimetres, or any other metric scales. Whilst a "scientific" analysis might conclude that there is a wide and ill-defined range of physical phenomena that combine in an extremely complex fashion to produce the subjective impression of "beauty", in everyday reasoning it is as primitive a term as "tallness". We certainly do not distinguish between them in arguments such as:

He likes girls that are tall and beautiful.
Mary is not very tall but very beautiful.
He will probably like Mary.

Such considerations led Zadeh (1965) to develop a theory of *fuzzy sets* that closely paralleled that of classical set theory but allowed for "shades of grey" in set membership. He extended the definition of the *characteristic function* of a set to include not just the binary values 0 and 1 but also the continuous interval between them. In classical set theory the characteristic function of a subset maps the elements of the universal set into 1 if they belong to the subset and into 0 if they do not. Zadeh allowed the elements to take the values in between also and called them *degrees of membership* to the subset. He showed that it was possible to extend the normal set-theoretic operations such as union, intersection and complementation, in a simple and natural way to fuzzy sets with continuous characteristic functions.

Since Zadeh's original study there has been a rapid growth in the literature on fuzzy sets and their application to system theory, control engineering, psychological modelling, linguistics, and so on (Gaines & Kohout, 1977). The related logical calculus derived from fuzzy set theory in the same way that the classical predicate calculus may be related to conventional set theory is of particular interest for this paper and has been presented as a system for *fuzzy reasoning*. This logic has been found to be one already studied by the Polish logician Łukasiewicz (Rescher, 1969) and of particular importance since White (1979) has shown recently that it avoids paradoxes such as that of Russell's "barber" (Hughes & Brecht, 1976) which arise from the unrestricted use of the axiom of comprehension in naive set theory. Since its inception fuzzy set theory has been used to model human verbal reasoning and concept processing. Goguen (1974) takes a formal axiomatic approach to the notion of a "concept" in natural and artificial languages and shows within a very general category-theoretic framework that one obtains generalized fuzzy sets.

These considerations led Shaw & Gaines (1979, 1980) to propose a fuzzy set semantics for personal constructs that could deal with the analysis of entailment in repertory grids using rating scales. In this paper the fuzzy sets and logic have been left deliberately until this late section so that they do not confuse the basic discussion of systems of entailment and their derivation from grid data. Suppose in the discussion of section 4 one now assumes that the predicates **LHP** and **RHP** are not just true or false, but also have the possibility of intermediate degrees of membership to being true (with false interpreted as a degree of membership of 0 to being true). Then the rest of the discussion of that section follows virtually without change but one now has a model of entailment in grids whose values are not binary. The implication and entailment operations are now those of Łukasiewicz multivalued logic and entailment holding between two poles is now not just true or false but can also take intermediate values.

The program ENTAIL described in section 5 has been written to take into account such multivalued data (as have INGRID, QARMS and FOCUS). The discussions of sections 6, 7 and 8 also generalize immediately to multivalued data and logics. Clearly the logic system itself now provides another measure of the "strength" of an entailment and we can see that what is discussed in section 6 differs from this in measuring the strength to which the entailment is verified as being present. Since Łukasiewicz logic defaults back to the standard propositional and predicate calculi when intermediate values are not used (Gaines, 1978) it is actually more convenient to develop the whole of the theory of construct structures and analysis described here directly in terms of fuzzy logic and this would seem appropriate for future studies.

One important feature of Zadeh's work has been its emphasis on the linguistic nature of human reasoning and the use of fuzzy set theory to model the use of *hedges* such as *very* and *rather* in human reasoning. This is similar to the interpretation of the points on a rating scale in terms of such hedges as "very", "slightly" and "quite" used in semantic differential techniques (Osgood, Suci & Tannenbaum, 1957). Thus there are natural verbal interpretations of the rating scale when values are input and these may also be applied to the equivalent values resulting from the ENTAIL analysis. One may say that there is a "quite strong" or a "very strong" entailment from one pole to another. Our requirement that the terminology and concepts of the analysis be those of the data thus continue to be satisfied in the extension to multivalued logics.

10. Extending entailment to compound predicates

The analysis of the entailment structure of a repertory grid given in section 4 was applied only to the atomic predicates and not to compounds such as **LHP1** OR **LHP2**, or **RHP3** AND **LHP5**. Since the truth values of all such compounds may be derived in any truth-functional logical calculus from the truth values of the components it is possible to extend the analysis to relations between components. There is no intrinsic technical problem except that the number of compound predicates that might be considered grows as a double exponentional of the number of atomic predicates. Thus a simple-minded extension to the techniques described in sections 4 and 5 produces an overwhelming mass of results.

Fortunately there are two properties of the entailment relation that greatly simplify the analysis. The first is that it is possible to represent the entailment from the disjunction of a number of predicates as the conjunction of a number of elementary entailments. We have:

$$(\mathbf{A}\ \mathrm{OR}\ \mathbf{B}\ \mathrm{OR}\ \mathbf{C}\ \mathrm{OR}\ldots)\rightarrow\mathbf{X}\equiv(\mathbf{A}\rightarrow\mathbf{X})\ \mathrm{AND}\ (\mathbf{B}\rightarrow\mathbf{X})\ \mathrm{AND}\ (\mathbf{C}\rightarrow\mathbf{X})\ \mathrm{AND}\ldots. \tag{20}$$

So that it is possible to neglect such compounds as that on the left-hand side of (20) in the analysis and consider only the atomic forms on the right-hand side.

A similar consideration applies to the conjunction of propositions on the right-hand side of an entailment. We have

$$\mathbf{X}\rightarrow(\mathbf{A}\ \mathrm{AND}\ \mathbf{B}\ \mathrm{AND}\ \mathbf{C}\ \mathrm{AND}\ldots)=(\mathbf{X}\rightarrow\mathbf{A})\ \mathrm{AND}\ (\mathbf{X}\rightarrow\mathbf{B})\ \mathrm{AND}\ (\mathbf{X}\rightarrow\mathbf{C})\ \mathrm{AND}\ldots. \tag{21}$$

So that it is possible to neglect such compounds as that on the left-hand side of (21) in the analysis and consider only the atomic forms on the right-hand side.

We also have that adding a further predicate conjunctively to the left-hand of an entailment or disjunctively to the right-hand leads to a derived entailment. That is, if we have

$$\mathbf{A}\rightarrow\mathbf{X}, \tag{22}$$

then we also have, for any **B**,

$$(\mathbf{A}\ \text{AND}\ \mathbf{B}) \to \mathbf{X} \tag{23}$$

and

$$\mathbf{A} \to (\mathbf{X}\ \text{OR}\ \mathbf{B}). \tag{24}$$

From these considerations and the transitivity of entailment it is possible to provide a set of entailments between compound propositions that serves as a base for deriving all others. This form of compound analysis comes closer than does the basic ENTAIL analysis of Fig. 5 to Pask's (1975) form of "entailment structure" analysis of subject matter for learning. If certain predicates are thought of as *outputs* to be derived from the others which are *inputs* then the entailment analysis can be seen to be closely related to the analysis of switching functions in both binary and fuzzy automata theory (Kandel & Lee, 1979).

11. Negation, opposites and relevance

A number of times in this paper we have noted that the role of the two poles of a construct as *opposites* has not been adequately treated. In our logical analysis the left-hand pole and the right-hand pole have been treated as distinct predicates of equal status. We have noted (sections 4 and 7) that the conventional elicitation of constructs leads to an inverse relation between the poles such that the predicate corresponding to one pole behaves as the logical *negation* of that corresponding to the other. This should perturb us since it appears to lead to precisely those defects of formal logic that Kelly warns against (Kelly, 1955, p. 106):

> Now conventional logic would say that black and white should be treated as separate concepts. Moreover, it would say that the opposite of black can only be stated as not black, and the opposite of white can only be stated as not white. Thus the person whose field we mentioned would have shoes which would be just as much not white as the time of day, and he would write on paper which would be just as not black as the distance to his office.

Part of the problem that Kelly is discussing here is one of *relevance.* "Not white" is a predicate relevant to shoes but not to the time of day. The standard predicate calculus fails to distinguish between "not" and "not relevant". We noted in section 1 that it is only in recent years that logics accounting for "relevance" in a very formal sense have been established (Anderson & Belnap, 1975). However, what even such logics do not encompass and Kelly brings out is the psychological role of the concept of *opposite* which has no logical counterpart—it is related to negation but not identical to it.

This introduction of the importance of modelling the role of opposites in human thinking is not peculiar to Kelly but is a continuing theme in philosophy from early times. The Pythagoreans used a table of opposites in analysing entities with ten constructs such as "*limited–unlimited*" and "*good–evil*". Mao Tsetung in his essay "On Contradiction" emphasizes the essential interdependence of opposites (Mao Tsetung, 1937, p. 61):

> no contradictory aspect can exist in isolation. Without its opposite aspect, each loses the condition for its existence.... Without life, there would be no death;

> without death there would be no life. Without above there would be no below; without below there would be no above .... It is so with all opposites; in given conditions, on the one hand they are opposed to each other, and on the other hand they are interconnected, interpenetrating, interpermeating and interdependent.

Mao also brings in the notion of relevance in defining opposites and uses the notions of contradiction yet identity amongst opposites in his exposition of an epistemology which closely mirrors Kelly's constructive alternativism.

This line of reasoning can be traced back through Lenin (1914) to Hegel whose basic logic of *thesis* and *antithesis* leading to a *synthesis* is founded on what seems to be the most careful distinction between opposite and negation in the philosophical literature. Hegel distinguishes between negation as an *absolute* difference and opposition as an *essential* difference, and Bogomolov singles this out as the foundation of dialectical logic (Bogomolov, 1977, p. 137):

> the investigation of the relation of two objects ... begins with establishing the *difference* between them, expressed in the most general form, with their mutual negation (A and ~A). To put it differently the second object acts initially as the simple negation of the first and is naturally expressed in logic by its indefinite negation .... Describing this kind of development of the concept, Hegel saw in it the transition from absolute difference to essential difference (variety), and from this to opposition (antithesis), as one of the stages of the general path from identity through difference to *contradiction*.

Thus we may see that Hegel's dialectics is crucially dependent on the transition from the concept of general negation to that of opposition. An opposite is some basis for there being negation, some *reason* for it, and it is the underlying construct to which this opposition is *relevant* that Hegel regards as the "synthesis" of the opposition between thesis and antithesis. Thus there is a close relationship between the epistemology put forward by Kelly and that put forward by previous philosophers concerned with dialectics. However, neither Pythagoreans nor Hegelians justify in logical terms their assertion that opposites are fundamental to reasoning. Kelly does not himself do so except by quotations like that at the beginning of this section which point out by example the difference between the negation of a construct and an opposite to it. Indeed one may argue from the presentation so far of a classical logical analysis of the repertory grid that in its original form it has already lost the possibility of coping with either relevance or the distinction between negation and opposition.

If we start with essentially bipolar constructs such that an element must be assigned to one, and only one, pole then we cannot treat relevance within a uniform framework. Kelly has to introduce it separately in terms of constructs having a "range of convenience". However, by considering an element to have quite distinct assignments to the two poles of a construct, i.e. to a construct and its "opposite" we can also capture the concept of relevance. A construct is *irrelevant* to an element if the element is assigned to neither of its poles (or, in the context of fuzzy logic, if its degree of membership to both poles is zero). Thus, in terms of Kelly's example at the beginning of this section the construct "*white–black*" is irrelevant to the time of day because it is both *not white* and *not black*. Those who extended his bipolar notion to allow for multipoint rating scales also failed to allow for relevance when they made the scales a one-dimensional interpolation between the two poles of a construct. However, the approach taken here is readily extended to the multipoint case by allowing separate ratings on the two poles of the construct. It is clearly debatable still whether this explication of relevance captures all its psychological connotations. We would suggest only that it captures some key ones.

What we have proposed is a very simple extension of Kelly's repertory grid methodology that gives us a logic capable of dealing with relevance and Kelly's notion of a "range of convenience". The mechanism used is crucially dependent on every predicate having an "opposite" so that one can distinguish between the predicate being *not true* for an element (element assigned to opposite predicate) and its being *not relevant* for the element (element assigned to neither predicate nor opposite). This demonstrates the importance of the concept of an "opposite" emphasized by so many different philosophers and gives a formal model for the utility of opposites. In previous papers we have analysed the semantics of opposite predicates and developed various logical constraints upon them (Shaw & Gaines, 1979, 1980). However, in the present context of repertory grid analysis an opposite predicate is just whatever the person from whom the grid is elicited chooses it to be. The ENTAIL analysis will cope with assignments to the two poles of a construct that are completely unconstrained in their mutual relationships.

The possibility of making separate assignments to the two poles of a construct and of analysing such extended forms of the repertory grid seems significant for a number of applications already noted in the literature. Slater (1977, p. 46) points out that missing data creates major problems for distance-based grid analysis, and yet it is a common problem. Kelly states (Kelly, 1955, p. 271):

> The assumption which is specific to a grid form of the test is that all the figures fall within the range of convenience of the constructs.... This may not be a good assumption in all cases; it may be that the client has left a void at a certain intersect simply because the construct does not seem to apply one way or the other.

Landfield (1976, p. 97) gives an example of a grid elicited from a patient which goes beyond this and allows the two additional values "N" for neither pole applicable and "?" for either pole applicable. In terms of our discussion above his "N" corresponds to an assignment of false to both poles and his "?" corresponds to an assignment of true to both poles. Thus the grid he elicits is readily analysed by ENTAIL. Obviously when ENTAIL analyses a particular entailment between a pair of poles under these circumstances it is relative to the elements actually construed in relation to those poles. However, it is possible to provide an analysis which does draw as much as possible out of the data given and does not crucially depend on all elements being assigned to one pole of every construct.

It is interesting to note that the logic being used by ENTAIL to deal with Landfield's four "truth values" is precisely that proposed by Belnap (1976) to deal with the epistemology of database systems. He proposes to deal with both missing and contradictory information in a database by allowing four values: *Told True*; *Told False*; *Not Told*; *Told True and Told False.* Gaines (1979) shows that such a logical structure also avoids the possibility of paradoxes such as that of Russell's barber arising through the imposition of semantic constraints on a database, and suggests the extension of the logic to continuous values in order to avoid deeper paradoxes. Again in this one can see the significance of the separate treatment of the opposite of a predicate in establishing a logic that is pragmatically sound.

12. Interactive construct elicitation and analysis

In section 13 we shall discuss how some of the unresolved problems of the logic of personal constructs may be resolved through a "dialectical" approach in which an interactive computer is used to explore the results of the analysis. It would be easy to assume that such interactive programs are merely more convenient ways of eliciting construct systems through extensions of Kelly's repertory grid and do not themselves add anything qualitatively new to the process. However, such an assumption would be missing centain crucial psychological factors in the man–computer situation and its differences from the man–man situation. We have observed informally in making PEGASUS available to a wide range of people in a variety of situations that those coming to it for the first time often seem to find it a very dramatic experience. They react to it intensely and become gripped by the interactive process of construct elicitation. They also feel that they are learning something new from the process and are prepared to use this in determining their behaviour.

Probably such involvement is also significant in the elicitation of construct systems by a person rather than computer interaction. However, we believe there are certain quite fundamental differences when the elicitation is done in such a way that interpersonal interaction is clearly absent. In particular, when a *person* is feeding back comments and guidance it is a natural and ready assumption that the constructs are being *injected* rather than elicited. It is easy for the subject to believe that the elicited constructs do not come from himself but that a tutorial or debating situation with another person is taking place. It is necessary to *persuade* him that this is not so and the persuasion has to be stronger the more striking and significant the constructs elicited. However, when a computer is the tool by which his construct structure is being reflected or laid bare then such an assumption of outside injection and interference is far less tenable.

When constructs are being elicited by a computer program then it is more likely to be accepted that it is precisely and only oneself that is being portrayed. We "trust" a computer program to be doing just what it appears to be doing without deeper motivations and without attempting to persuade us to its point of view. No-one is telling the user anything. He is seeing in interacting with PEGASUS, possibly for the first time, the basis for his own thought processes. Very often extreme surprise is the first reaction. If another person were eliciting the construct structure then the surprise would be taken as an indication that he was incorrect and one would ignore him or argue with him. With computer elicitation it is more likely that one will accept the reflected structures as being self-generated and the surprise acts as motivation to know more.

That this knowledge can be totally private to oneself is another important feature of interaction with the computer. We do not like, as Kelly put it, to be "caught with our constructs down". When another person is involved we are more reluctant to expose and explore our constructs the more surprising they are; perhaps because the surprise is often the result of a conflict between our ostensive value judgements and the basis of our behaviour. Or it may just be sloppy verbal behaviour: that we are naming two distinct constructs with the same label. For example, in using PEGASUS a scientist found that he was using the word "time" to label several different constructs and generating confusion in his arguments because of this.

Another reason that we are reluctant to explore construct structures freely in interacting with another person, particularly a professional person, is that we are acutely aware of the possible "waste" of their time. This phenomenon has been noted (Card, Nicholson, Crean, Watkinson, Evans, Witson & Russell, 1974) as accounting for a major part of the preferences expressed by patients to be interviewed through an interactive computer program rather than their doctor. There are many pressures and artefacts of interpersonal relationships that can totally obscure and undermine such reflective processes as we require in the elicitation of personal constructs.

It is interesting to note that this argument has been put in reverse: Adams (1979) notes that children learn quickly to play games on a personal computer and conjectures that this is because of the lack of interpersonal complications. She suggests, however, that "one of the benefits of game-playing is that a child learns how to behave with and towards others, how to cope with success and failure, and what effect it has on others. In the human–computer relationship the child does not learn these valuable social skills." We are arguing conversely that the need to be deploying such "social skills" is a load that can seriously detract from the exploration of the self.

A notable technical feature of PEGASUS that profoundly affects human reactions to it is that relationships between constructs may be inferred instantly and queried with the user. This immediate analysis and feedback is a key factor in most applications of interactive computers and can go way beyond what any manual analysis can accomplish. Instant feedback whilst one remembers one's line of reasoning is very different from delay analysis that arrive at a later time when the entire context of the replies one has been giving may have been forgotten. Construct structures in particular have a high degree of context-dependence. It is often the relationship between the structures elicited and the *role* we are adopting in answering the questions that elicit them which is of prime interest to us. Using Wolff's (1976) terminology, we *surrender* ourselves to a particular role and become a "physicist", a "mathematician", a "manager", a "father", etc., and it is the analysis of our construal of the world in the specific role which we are attempting to *catch*.

These aspects of the computer elicitation of repertory grids with immediate feedback of the results of the analysis were those that led to our study of more powerful logical tools for analysing grids. In the next section we consider some of the implications of the discussion earlier in this paper for extending PEGASUS.

13. Database dialectics

This section is the most speculative of the paper since it represents work to be done rather than that already completed. We are presenting here the new directions in construct elicitation that follow from the discussion of this paper both in terms of how the analytical results can aid the elicitation and also in terms of how the availability of direct interaction can aid the analysis. To make the discussion of this section more pointed we present a number of specific recommendations for the further development of interactive construct elicitation systems.

In terms of the discussion of the preceding section it seems reasonable to suggest that one takes an existential view of the phenomenon of computer elicitation of personal constructs regardless of one's view of Kelly's theory and methodologies based on it. The computer interaction is in itself a meaningful and significant experience for many people and they gain from it. Perhaps it is only that introspection is not a skill developed by most current educational systems. We promote the "received view" of knowledge and act as teachers to bring the minds of students into conformity with our consensual models of reality. What you think does not matter in itself, only that it does not deviate from what it is "correct" to think. It is a novel experience for many people to realize that there are actually individualistic thought processes going on within them. It is even more novel for them to realize that these condition "reality" and that different approaches to life and different reactions to the same circumstances may be ascribed to different construals of reality.

Thus our objectives in developing PEGASUS are to set up a suite of interactive computer programs that enable people to explore their own "realities", singly or in groups, through an open-ended "discussion" of freely chosen elements and constructs and the relations between them. Currently a view of reality is expressed as a grid giving ratings of elements on a scale between the poles of constructs. A collection of such grids is precisely equivalent to a *relational database* (Codd, 1970) with constructs as field names and elements as objects in the database. Thus our first generalization from PEGASUS is to work with a general database that contains the grids as relational entities:

Recommendation 1: Regard a construct elicitation program as building up a database in which construed elements are objects in the database and the constructs determine field names.

In section 11 we advanced reasons why one should allow ratings to be separately assigned to each of the poles of a construct and hence a second generalization is:

Recommendation 2: Assign a separate field for each pole of a construct and allow a degree of membership to be assigned independently to each.

Note that this is not intended to preclude the conventional form of grid in which the rating on one pole is the complement of that on the other. It allows for the generalization and also for the conventional usage.

Gaines (1979) analyses some of the defects of current relational database implementations and notes the need for fuzzy predicates to be allowed even when apparently definite values are assignable. For example we may wish to say that someone is either in department X or department Y. This can be represented by giving a degree of membership of unity to both these departments and to no others. It seems useful to allow for such conventional data base fields in this extended form to be stored also even if they are not conventional examples of constructs:

Recommendation 3: Allow conventional database items to be stored with a field for each value to which a degree of membership may be assigned.

One important feature of PEGASUS is its conversational mode of operation but this currently involves the use of rating scales which can seem somewhat artificial. We have already noted that it is possible to replace these with fuzzy hedges such as "slightly" and "very", and it seems desirable to incorporate this facility into any new system:

Recommendation 4: Allow for rating scale values or degrees of membership to be entered linguistically as fuzzy hedges.

The database itself should be accessible for interrogation, modification and deletion through any reasonable access path, and the presentation and modification of data should also be linguistic where appropriate:

Recommendation 5: Allow access to the database for interrogation, deletion and modification through normal database access mechanisms and present the data in the linguistic form in which it was entered.

The results of an ENTAIL analysis are essentially degrees of membership to equivalences and entailments or preferences. These may also be expressed linguistically through the use of fuzzy hedges, and other relevant features of the analysis such as the use of the quantifier "usually" may also be presented in this way:

Recommendation 6: Express the results of the database analysis in linguistic terms using the same hedges as those used in setting it up.

Another important feature of PEGASUS is the way in which it directs the dialogue in eliciting constructs by feeding back information about closely related constructs or elements and asking the user to provide further data to split them. The following dialogue with PEGASUS in the context of "exploring learning situations" demonstrates this process in action (Shaw, 1980, pp 61–62):

```
THE TWO CONSTRUCTS YOU CALLED
 2 FLEXIBLE-RIGID
 6 VARIABLE CONTENT-SPECIFIC CONTENT
ARE MATCHED AT THE 85 PERCENT LEVEL
THIS MEANS THAT MOST OF THE TIME YOU ARE SAYING
FLEXIBLE YOU ARE ALSO SAYING
VARIABLE CONTENT
AND MOST OF THE TIME YOU ARE SAYING
RIGID YOU ARE ALSO SAYING
SPECIFIC CONTENT
THINK OF ANOTHER ELEMENT WHICH IS EITHER FLEXIBLE AND
SPECIFIC CONTENT
OR VARIABLE CONTENT AND RIGID
IF YOU REALLY CANNOT DO THIS THEN JUST PRESS RETURN AFTER
THE FIRST QUESTION MARK, BUT PLEASE TRY. THEN YOU MUST GIVE
THIS ELEMENT A RATING VALUE ON EACH CONSTRUCT IN TURN. TYPE
A VALUE FROM 1 TO 5 AFTER EACH QUESTION MARK.

WHAT IS YOUR ELEMENT?VIDEO TAPE
RATINGS:
INVOLVEMENT-REMOTENESS?3
FLEXIBLE-RIGID?2
...........................
```

This type of feedback is readily generalized to other forms of analysis such as that produced by ENTAIL. A similar dialogue might contain:

```
WHENEVER YOU SAY "RUNS" OF A PERSON
YOU ALSO SAY "ENERGETIC"
CAN YOU THINK OF A PERSON WHO IS "RUNS"
BUT WHO IS NOT "ENERGETIC"
```

This leads to the recommendation:

Recommendation 7: Offer a mode of database elicitation in which significant features of the structural analysis are fed back to the user to encourage exploration of the data space.

Clearly, the feedback should follow recommendation 6 and use linguistic terms. The "85 PERCENT LEVEL" mentioned in the first example above has no equivalent in the user's vocabulary and requires a user to have some technical knowledge to interpret it.

We have commented a number of times in this paper on the problem of determining whether the results of an analysis are just artefacts of particular data or represent significant relations that are *necessary* in some sense. There are mathematical techniques for evaluating the *significance* of analyses but these all depend on fairly strong assumptions about some form of *distribution* from which the data is a sample. Such assumptions are singularly inappropriate for personal construct data where one is examining the data structure of an individual in restricted circumstances. In this context it seems more appropriate to ask the users themselves to verify the meaningfulness of the analyses for themselves:

Recommendation 8: Feed back the results of the analysis to the user and ask him to rate the meaningfulness or significance of each part of it.

The feedback of recommendation 7 is related to this process in that it gives the user the opportunity to change the analysis in a critical way by adding data that does not conform with it. This may be thought of as a "Popperian" mode of falsification of hypothesis through the search for confounding data, whereas recommendation 8 allows for this by command. A failure to agree with the analysis whilst at the same time being unable to produce a counter-instance might correspond to the dissociation between behaviour and verbalization discussed in section 7.

The converse failure to agree with the analysis is, for example, to feel that an entailment should exist which is not derived. In this case the user should be able to ask the system for the evidence against the supposed relation. For example:

```
WHY NOT ENERGETIC MEANS RUNS
BECAUSE YOU SAID JACK IS "ENERGETIC" BUT NOT "RUNS"
```

This leads to the recommendation:

Recommendation 9: Allow the user to propose possible analyses and reflect back to him evidence from the database which disconfirms these.

PEGASUS has no inbuilt knowledge of natural language and its "conversations" are somewhat stilted. This is even more apparent when one uses linguistic forms of analysis as in the example above. The success of elementary natural language conversational systems in recent years ranging from Weizenbaum's (1967) ELIZA through Winograd's (1972) SHRDLU to Harris's (1977) ROBOT leads one to believe that it may be possible to embed interactive construct elicitation within a framework of natural language conversational access to the database. For a while this will be possible only on fairly large machines rather than personal computers but the development seems worth undertaking:

Recommendation 10: Use a simple natural language analysis and generation system to enhance the conversational flow of interactive construct elicitation and analysis systems.

Other apparently advanced enhancements are also possible by noting that the element and construct names are just arbitrary symbols created by the user and that the PEGASUS vocabulary is very small and defined in advance apart from these. There are now simple and effective speech recognizers available for personal computers that discriminate some 30 or more words. There are similarly low-cost speech synthesizers that can be used not only with a pre-defined vocabulary but also to record and replay words input interactively. Thus it is possible to develop a form of interactive construct elicitation system which operates completely in a speech mode and requires no keyboard input or display output. In the current state of the technology it is likely that such systems will be curiosities rather than practical tools and we cannot recommend them in a practical sense. However, computer speech technology is developing rapidly and in time such systems will become practically important.

We conclude this section by emphasizing that our concept of future personal construct elicitation and analysis systems is one of a suite of programs operating around a database. The programs will allow various forms of entry of data to the database coupled with a wide range of analysis techniques including all those compared in this paper.

14. Conclusions

In this paper we have shown how a repertory grid may be regarded as a logical structure in which the poles of constructs are predicates applying to the elements and have developed the foundations for a methodology of grid analysis based on this logical interpretation. We have given examples of such analysis produced by the computer program ENTAIL and compared it with other techniques such as INGRID, FOCUS and Q-Analysis. We have shown that the logical approach extends to grids using rating scales and also to grids in which there is independent rating on each pole.

We have attempted throughout the paper to present the new methodology in a way which clearly relates it to Kelly's original development of personal construct theory and demonstrates that it is a logical derivation from that theory. We have also linked the methodology to foundational work in logic which was not available to Kelly yet seems essential to sustain an accurate formalization of his work. We have emphasized also the peculiar significance of the interactive computer in allowing a dialectical, conversational approach to grid elicitation and analysis, and have shown how the logical approach using fuzzy linguistic semantics supports this approach.

This has been a fairly technical paper and it would be appropriate to end with a balancing reminder that the methodology and technology should not blind us to the problems of actually gaining knowledge of personal constructs and their structures. The repertory grid, no matter how it is enhanced, is only a tool for allowing us to gain some view of a person's construct space. It is a powerful tool but by no means a comprehensive one. It gives us a simplified, partial representation of the very much richer processes underlying human reasoning. *Logic* derives from these processes, not they from it, and we should beware of forcing human reasoning into a Procrustean bed of mathematical theory. The multivalued, modal logics used in this paper are a long way from the basic predicate calculus developed by Frege in setting up formal foundations for arithmetic. These modern developments in logic seem to provide adequate foundations for Kelly's personal construct psychology. However, we should always retain a suspicion that continuing development and refinement will always be necessary for any formal structure that purports to capture the processes of the human mind.

In the final section we have given a set of recommendations for the direction of future development of interactive construct systems which are those guiding our own work. In particular we see a convergence between work on relational databases, expert systems and personal construct elicitation. The personal computer systems of the future will be tools that complement the minds of their users and work together with them at a high level of mental symbiosis. The major use of computers to date has been "technical cognitive" to use Habermas' (1968) evocative phrase for the situation in which the technology dominates and controls the user. We see interactive construct elicitation and analysis systems as providing an "emancipatory cognitive" technology in Habermas' terms that encourages the user to comprehend, change and develop in his own fashion by reflecting back to him the essence of his own approach to various aspects of his life.

Many people over the years have influenced the direction of this work. We owe particular thanks to Ron Atkin, John Gedye, Joe Goguen, Susan Haack, Ladislav Kohout, Ebrahim Mamdani, Gordon Pask, Laurie Thomas, Francisco Varela and Lotfi Zadeh. We are grateful to Simon Hasleton for the INGRID analysis of Fig. 2.

References

ADAMS, J. (1979). Pet behaviour. *Practical Computing*, **2**, 29.

ANDERSON, A. R. & BELNAP, N. D. (1975). *Entailment.* New Jersey: Princeton University Press.

ATKIN, R. H. (1974). *Mathematical Structure in Human Affairs.* London: Heinemann.

AYER, F. J. (1936). *Language, Truth and Logic.* London: Victor Gollancz.

BAINBRIDGE, L. (1979). Verbal reports as evidence of the process operator's knowledge. *International Journal Man–Machine Studies*, **11**, 411–436.

BANNISTER, D. & FRANSELLA, F. (1971). *Inquiring Man.* U.K.: Penguin.

BELNAP, N. D. (1976). How a computer should think. In RYLE, G., Ed., *Contemporary Aspects of Philosophy*, pp. 30–56. Stockfield: Oriel Press.

BOGOMOLOV, A. S. (1977). Dialectical contradiction and its solution. Concerning the central problem of dialectical logic. In *Philosophy in USSR. Problems of Dialectical Materialism*, pp. 134–156.

BRADLEY, R. & SWARTZ, N. (1979). *Possible Worlds.* Oxford: Blackwell.

CARD, W. I., NICHOLSON, M., CREAN, G. P., WATKINSON, G., EVANS, C. R., WILSON, J. & RUSSELL, D. (1974). A comparison of doctor and computer interrogation of patients. *International Journal Biomedical Computing*, **5**, 175–187.

CODD, E. F. (1970). A relational model of data for large shared data banks. *Communications of Association for Computing Machinery*, **13**(6), 377–387.

CRESSWELL, M. J. (1973). *Logics and Languages*. London: Methuen.
DURAN, B. S. & ODELL, P. L. (1974). *Cluster Analysis: A Survey, Lecture Notes in Economics and Mathematical Systems 100.* Berlin: Springer.
FEYERABEND, P. (1975). *Against Method.* London: NLB.
GAINES, B. R. (1976). Foundations of fuzzy reasoning. *International Journal Man–Machine Studies*, **8**, 623–668.
GAINES, B. R. (1978). Fuzzy and probability uncertainty logics. *Information and Control*, **38**, 154–169.
GAINES, B. R. (1979). Logical foundations for database systems. *International Journal Man–Machine Studies*, **11**, 481–500.
GAINES, B. R. & KOHOUT, L. J. (1977). The fuzzy decade: a bibliography of fuzzy systems and closely related topics. *International Journal Man–Machine Studies*, **9**, 1–68.
GELLNER, E. (1974). *Legitimation of Belief.* Cambridge: Cambridge University Press.
GLANVILLE, R. (1980). Construct heterarchies. *International Journal Man–Machine Studies*, **13**, 69–79.
GOGUEN, J. A. (1974). Concept representation in natural and artificial languages: axioms, extensions and applications for fuzzy sets. *International Journal Man–Machine Studies*, **6**, 513–561.
HAACK, S. (1979). Do we need "fuzzy logic"? *International Journal Man–Machine Studies*, **11**, 437–445.
HABERMAS, J. (1968). *Knowledge and Human Interest.* London: Heineman.
HARRIS, L. R. (1977). User oriented data base query with the ROBOT natural language query system. *International Journal of Man–Machine Studies*, **9**(6), 697–713.
HINKLE, D. N. (1965). The change of personal constructs from the viewpoint of a theory of implications. Ph.D. thesis, Ohio State University.
HOGAN, R. (1976). *Personality Theory: The Personological Tradition.* New Jersey: Prentice–Hall.
HUGHES, P & BRECHT, G. (1976). *Vicious Circles and Infinity.* London: Jonathan Cape.
KANDEL, A. & LEE, S. C. (1979). *Fuzzy Switching and Automata.* New York: Crane Russak.
KELLY, G. A. (1955). *The Psychology of Personal Constructs.* New York: Norton.
KELLY, G. A. (1970). A brief introduction to personal construct theory. In *Perspectives in Personal Construct Theory.* London: Academic Press.
KORZYBSKI, A. (1933). *Science and Sanity.* Connecticut: International Non-Aristotelian Library.
KUHN, T. S. (1962). *The Structure of Scientific Revolutions.* Chicago: University of Chicago Press.
LANDFIELD, A. (1976). A personal construct approach to suicidal behaviour. In SLATER, P., Ed., *Dimensions of Intrapersonal Space*, Vol. 1, pp. 93–107. London: Wiley.
LEMMON, E. J. (1966). Algebraic semantics for modal logics. *Journal of Symbolic Logic*, **31**, 46–65, 191–218.
LENIN, V. I. (1914). Conspectus of Hegel's book The Science of Logic. In *Collected Works*, **3**. London: Lawrence & Wishart.
LEWIS, D. (1973). *Counterfactuals.* Oxford: Blackwell.
LICKLIDER, J. C. R. (1960). Man–computer symbiosis. *I.R.E. Transactions on Human Factors in Electronics*, **HFE-1**, 4–11 (March).
MAO TSETUNG. (1937). *Five Essays on Philosophy.* Peking: Foreign Languages Press.
MICHALSKI, R. S. & CHILAUSKY, R. L. (1980). Knowledge acquisition by encoding expert rules versus computer induction from examples; a case study involving soybean pathology. *International Journal Man–Machine Studies*, **12**, 63–88.
MICHIE, D., Ed. (1979). *Expert Systems in the Micro Electronic Age.* Edinburgh: Edinburgh University Press.
OSGOOD, C. E., SUCI, G. J. & TANNENBAUM, P. H. (1957). *The Measurement of Meaning.* Urbana: University of Illinois Press.
PASK, G. (1975). *Conversation, Cognition and Learning.* Amsterdam: Elsevier.
POPPER, K .R. (1972). *Objective Knowledge.* Oxford: Clarendon Press.
RESCHER, N. (1969). *Many-Valued Logic.* New York: McGraw-Hill.
SHAW, M. L. G. (1980). *On Becoming a Personal Scientist.* London: Academic Press.

SHAW, M. L. G. & GAINES, B. R. (1979). Externalizing the personal world: computer aids to epistemology. In *Improving the Human Condition: Quality and Stability in Social Systems*, pp. 136–145. Kentucky: Society for General Systems Research.

SHAW, M. L. G. & GAINES, B. R. (1980). Fuzzy semantics for personal construing. In *Systems Science and Science*, pp. 146–154. Kentucky: Society for General Systems Research.

SLATER, P., Ed. (1976). *Dimensions of Intrapersonal Space*, Vol. 1. London: Wiley.

SLATER, P., Ed. (1977). *Dimensions of Intrapersonal Space*, Vol. 2. London: Wiley.

SNYDER, D. P. (1971). *Modal Logic*. New York: Van Nostrand Reinhold.

SPENCER BROWN, G. (1969). *Laws of Form*. London: George Allen & Unwin.

VARELA, F. J. (1975). A calculus for self-reference. *International Journal General Systems*, **2**, 5–24.

VARELA, F. J. (1979). *Principles of Biological Autonomy*. New York: North-Holland.

WASON, P. C. & JOHNSON-LAIRD, P. N. (1972). *Psychology of Reasoning*. London: B. T. Batsford.

WEIZENBAUM, J. (1967). Contextual understanding by computers. *Communications of Association for Computing Machinery*, **10**(8), 474–480.

WHITE, A. R. (1975). *Modal Thinking*. Oxford: Blackwell.

WHITE, R. B. (1979). The consistency of the axiom of comprehension in the infinite-valued predicate logic of Łukasiewicz. *Journal of Philosophical Logic*, **8**(4), 509–534 (November).

WINOGRAD, T. (1972). *Understanding Natural Language*. Edinburgh: Edinburgh University Press.

WOLFF, K. H. (1976). *Surrender and Catch*. Holland: Reidel.

ZADEH, L. A. (1965). Fuzzy sets. *Information and Control*, **8**, 338–353.

ZADEH, L. A. (1976). A fuzzy algorithmic approach to the definition of complex or imprecise concepts. *International Journal Man-Machine Studies*, **8**, 249–291.

Subjective multi-criteria decision making

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This paper outlines the principles of a new technique used in operationalization of subjective decision making, in general, and multi-criteria decision processes in particular. The work is based on the psychological theory of personal constructs, introduced by George Kelly in 1955, and highlights the greater emphasis which should be placed upon personal judgement and individual values. The principles of repertory grids are employed as the basis for implementation of this idea.

CODEM2—*CO*nversational *DE*cision *M*aking—is the interactive software tool developed in the course of this work. Operational detail of this program is exemplified through an appropriate example.

1. Introduction

It is inevitable that in situations embodying vagueness the process of decision making becomes more than a mere rational and a purely analytic exercise. Such situations highlight the greater significance acquired by personal judgement, individual values and intuition.

In this paper are outlined the principles and techniques used in operationalization of subjective decision making. The work is based on the theory of personal construct introduced by George Kelly in 1955. The method is based on the principles of repertory grids.

Previous works have introduced the element of subjectivity into the multi-criteria decision problems, either through the psychological apparatus of Kelly's personal construct theory, as in Boxer (1979), or, without recourse to Kelly's theory, through linguistic properties of fuzzy sets (Eshragh, 1979). The methods described in this paper, evolved from both the above-mentioned works. It aims at solidifying the foundations upon which subjectivity rests in order to enable option selection in a multi-criteria decision environment.

2. Linguistic realization of rating grid for subjective multi-criteria decision making

The main theme of this work is that of a computer-assisted decision making procedure. CODEM2 is a computer program which is used for this purpose and has evolved from an earlier one called CODEM1 (further detailed information can be obtained from Eshragh (1979)).

The decision making procedure is fairly simple. Given a multi-criteria problem, the user defines his decision space, subjectively, by using fuzzy linguistic statements. That is, the user first defines a set of alternatives which he wishes to study. Then, a certain number of criteria or evaluative concepts, in terms of which alternatives are rated, can be defined. The next item which has to be defined is the expression of the decision maker's attitude towards the kind of alternative that he requires. If the decision maker is selecting a motor car by considering n cars with respect to m evaluative concepts, he would also define an $(n+1)$th fictitious car whose ratings, in terms of his defined evaluative criteria, would be his required ones. For example, if two cars, *CAR1* and *CAR2*, are under study in terms of *price*, *consumption* and *reliability*, the decision maker may define a 3×3 decision matrix as shown in Fig. 1.

	CAR1	*CAR2*	*CAR(GOAL)*
Price	High	Fairly Low	Average
Consumption	Average	Indeed High	Low
Reliability	Extremely high	Very low	NOT low AND NOT high

FIG. 1. Decision matrix for car selection problem.

The third alternative, henceforth called *goal alternative*, plays the role of both weights and utility as usually used in the solution of multi-criteria problems (see Efstathiou, 1979; Baas & Kwarkernaak, 1977; Baldwin & Guild, 1978).

To sum up, CODEM2 is used in a three-phase procedure

(i) Identification,
(ii) Evaluation,
(iii) Investigation.

The first phase deals with identification of elements (options), criteria and evaluative concepts names. The second phase refers to the evaluation of options in terms of criteria and is quite different from the usual method used in rating grids. This phase is discussed more fully in a later section of this paper.

The final stage is the analysis phase of the decision making procedure. It is during this phase of the procedure that the decision maker selects the best policy.

2.1. THE EVALUATION OF OPTIONS (RATINGS)

The dichotomized nature of personal constructs underlies the rating procedure here. The rating is carried out not by explicitly marking the position of an alternative on a linear scale, as in Boxer's system, but, by the assignment of linguistic labels using both of the poles of a construct. There are four parts to this procedure:

(a) specification of the *concept and null point*;
(b) location of the point representing the *antonym of the concept*;
(c) evaluation of other *linguistic terms*;
(d) *restrictions on* the specification of the *concept and null point.*

(*a*) *Concept and null point*

In a given problem environment, every criterion is given a linear scale which can be treated as representing the closed interval [0, 1]. The decision maker is assumed to have named the concepts to be used for rating in terms of all criteria. For example, the adjective *beautiful* for the criterion *look* in a beauty contest. The user is then required to assume that all women are situated along the linear scale mentioned above, in ascending degree of beauty from left to right. Thus he is required to mark the position on the line which he considers a beautiful woman should be, *allowing* room for specification of *more* beautiful women. Similarly, he marks the *null* position—the point of neutrality. This configuration is shown in Fig. 2. This is synonymous to specifying primary fuzzy terms in CODEM1.

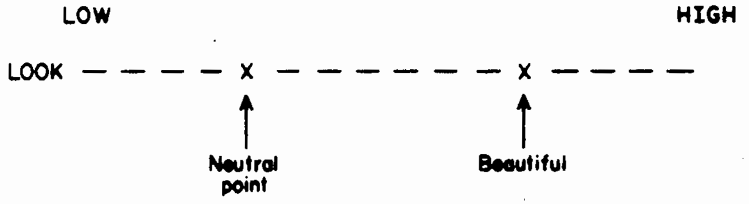


FIG. 2. Adjective marking.

The neutral point is the position below which the individual does not consider a beautiful woman should be placed. Below this point lie the set of *unbeautiful* or *ugly* women as the case may be.

(*b*) *The antonym position*

Having obtained the information shown in Fig. 2, the position of the antonym or the opposite pole of the concept should be calculated. This is done by dividing the linear scale into two parts at the neutral point. The two portions are then mapped into two other linear scales which are both normal, i.e. represent the closed interval [0, 1]. Knowing the mapping relationship, one can find the image of the concept and the null points on the normalized scale. On these normalized scales, the antonym of the original concept point with respect to the neutral point can be defined as the mirror image of the concept point, on the normalized scale, about the common null point. This point is then mapped back onto the original scale. For example, if $N_\emptyset$ represents the neutral point and N_1 represents the concept point, then $\bar{N}_1$, the position of the point representing the antonym of the concept can be calculated through the following equation:

$$\bar{N}_1 = N_\emptyset \times \left(1 - \left(\frac{N_1 - N_\emptyset}{1 - N_\emptyset}\right)\right).$$

Figure 3 shows the mapping arrangement in finding the antonym point.

It is important to note that the dichotomized poles of a construct are not necessarily symmetrical about the neutral point on the original scale. This can be inferred from the empirical work of Benjafield & Adams-Webber (1976). They showed that when subjects make dichotomous judgements in terms of bipolar dimensions, they will tend to use one adjective more than another. Specifically, they hypothesized that the ratio of the frequency of use is 62/38 in favour of the positive adjective. Similar findings have been reported by Dees (1973). Dees labels the dichotomous poles of a construct as *marked* and *unmarked* ones.

The unmarked adjective is the positive pole like *moral* in *moral–immoral* pair. The marked adjectives are created by the addition of a *single* feature. In the case of

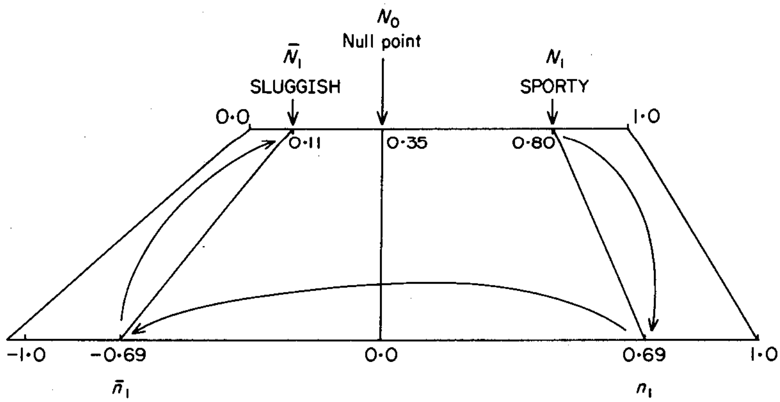


FIG. 3. Mapping of +ve and −ve adjective points. $n_1=(N_1-N_\emptyset)/(1-N_\emptyset)$; $\bar{n}_1=-n_1$; $\bar{N}_1=N_\emptyset(1+\bar{n}_1)=N_\emptyset[1-(N_1-N_\emptyset)/(1-N_\emptyset)]$.

kind–unkind this feature is the prefix *un*. Dees (1973) distinguishes between marked and unmarked members by pointing out that:

(i) unmarked members come into a language earlier;
(ii) unmarked members are more likely to occur;
(iii) children learn to use unmarked members first.

The fact that Dees (1973) believes that "the semantic relations are essentially psychological and not linguistic in nature" and the points stated above tend to substantiate this non-symmetry of the positioning of the adjective poles on a scale.

(*c*) *Translation of linguistic labels*

Other linguistic labels are evaluated by using the translation rules of fuzzy sets (see Eshragh, 1979). There is a slight modification as far as the hedges *very* and *more-or-less* (or *fairly*) are concerned. In order to preserve the semantic entailment properties of labels, the functions representing *very* and *more-or-less* had to be functionally interchanged. Other than this, the evaluation procedure is the same as in finding the position of the antonym of a concept. The operand of a linguistic label is first mapped onto the normalized scale. The calculation then takes place on the normalized scale and the result is transferred back on to the original scale. For example, if *kind* is positioned at 0·8 on the original scale with a neutral point at 0·3, then *very kind* and *more-or-less kind* are calculated as follows.

On the normalized scale, 0·8 is mapped to 0·71. *Very* and *more-or-less*, when operated on 0·71, give 0·84 and 0·55, respectively. When the values are transferred onto the original scale, their corresponding values would be 0·89 and 0·68.

An important point to notice here is that *not kind* is different from *unkind*, the opposite pole of *kind*. If *kind* and *unkind* were defined on either ends of the scale with the neutral point at 0·5, then *not kind* and *unkind* would be represented by the same point. This is quite a reasonable consequence of the fact that one who is *not kind* does not necessarily mean that he is *unkind*.

A special version of the translation program, described by Eshragh (1979) is used to cope with the translation of linguistic statement containing marked and unmarked adjectives. The modification comprises the treatment of the dichotomous concepts as primary terms which are defined by a fuzzy set which is defined on one point only.

(*d*) *Restriction on the concept and null point*

There may appear certain inconsistancy when *NOT* is used in conjunction with the adjectives. For example, if in a problem the concept *basic* is defined to be at 0·6 and its relative *null* point at 0·4, then *not basic* will be positioned at 0·796 which is on the right-hand side of the point representing *basic* as shown in Fig. 4.

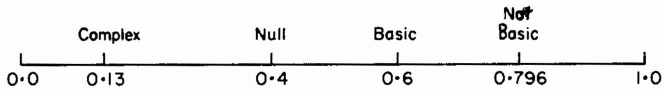


FIG. 4.

From the configuration outlined in Fig. 4, it can be discerned that *basic* is treated in a negative sense and naturally its negation would be more positive. This can be attributed to incorrect definition of the initial positioning of the concept.

It turns out that in order to avoid this problem, the value representing the concept position should be greater than half of null value plus 0·5. That is, if x represents the concept value and x_0 represents the null values then

$$x_1 < 0{\cdot}5x_0$$

$$x_2 < 0{\cdot}5 + 0{\cdot}5x_0$$

$$2x_1 < x_0 < 2x_2 - 1.$$

To prove this, consider the arrangement shown in Fig. 5.

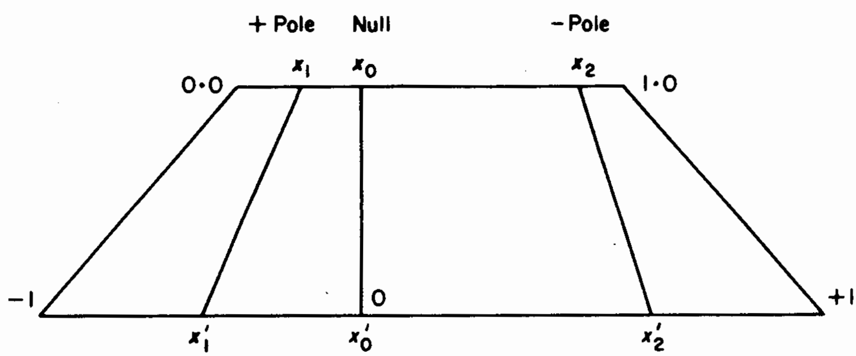


FIG. 5. Restriction on the concept and null point positions.

We have

$$x_2' = \frac{x_2 - x_0}{1 - x_0}, \tag{1}$$

$$x_1' = \frac{x_1}{x_0} - 1. \tag{2}$$

For consistency, the following should hold.

$$x_1' < -0{\cdot}5, \tag{3}$$

$$x_2' > 0{\cdot}5. \tag{4}$$

By substituting (1) in (4),

$$\frac{x_2 - x_0}{1 - x_0} > 0{\cdot}5,$$

$$x_2 > 0{\cdot}5 + 0{\cdot}5x_0. \tag{5}$$

Similarly, by substituting (2) in (3),

$$\frac{x_1}{x_0} - 1 < -0{\cdot}5,$$

$$x_1 < 0{\cdot}5x_0. \tag{6}$$

From (5) and (6) the following relationship between x_0, x_1 and x_2 can be established:

$$2x_1 < x_0 < 2x_2 - 1. \tag{7}$$

3. The analysis techniques

Having stated the decision problem and obtained the numerical representation of the decision matrix, three methods of analysis can be used. Two of these methods are based on cluster analysis and statistical techniques and the third is a simplified version of the linguistic approximation method outlined in Eshragh & Mamdani (1979). The former two are referred to as *dendrogram* and *pattern* diagrams and explained in Everitt (1974). In the sequel, these techniques will be briefly discussed.

3.1. DENDROGRAMS

Dendrograms are clustering diagrams which explain, graphically, the relationship and grouping of a number of variables. According to the metric used for the evaluation of distances, various dendrograms can be obtained. Everitt (1974) gives six different *nearest neighbour* methods whereby the distance between two vectors with n elements is calculated by averaging the distances between the corresponding elements of the two vectors.

The technique is best illustrated through an example. Consider the difference matrix for five elements shown below.

	1	2	3	4	5
1	0	0·2	0·6	1	0·9
2	0·2	0	0·5	0·9	0·8
3	0·6	0·5	0	0·4	0·5
4	1	0·9	0·4	0	0·3
5	0·9	0·8	0·5	0·3	0

The procedure is as follows:

(i) Find the smallest non-zero element in the matrix and merge its corresponding row and column. This merging can be either by taking an average or taking the minimum component value. The dimension of the matrix is now reduced by one and the row and column representing elements 1 and 2 are removed and replaced by a new one labelled (12). The differences between 1 and elements 12, 3, 4 and 5 are obtained as follows:

$$\mathrm{D}((1,2),3)=F\,(\mathrm{D}(1,3),\mathrm{D}(2,3)),$$
$$\mathrm{D}((1,2),4)=F\,(\mathrm{D}(1,4),\mathrm{D}(2,4)),$$
$$\mathrm{D}((1,2),5)=F\,(\mathrm{D}(1,5),\mathrm{D}(2,5)).$$

where $\mathrm{D}(I, J)$ is the element in the Ith row and Jth column of the original difference matrix. F is a function like min. or average.

The new difference matrix is

	(12)	3	4	5
(12)	0	0·55	0·95	0·35
3	0·55	0	0·4	0·5
4	0·95	0·4	0	0·3
5	0·85	5	0·3	0

(ii) Repeat (i) until a 2×2 matrix is obtained. In this example, by repeating the process twice the following two matrices would be obtained:

	(12)	3	(45)
(12)	0	0·55	0·9
3	0·55	0	0·45
(45)	0·9	0·45	0

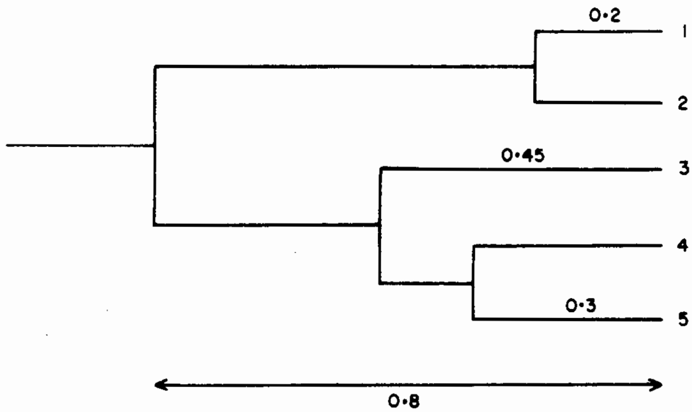
	(12)	3(45)
(12)	0	0·8
3(45)	0·8	0

Figure 6 shows the dendrogram representing this grouping instance.

3.2. PATTERN ANALYSIS

This analysis brings out the variation inherent among the options with respect to each criterion. The analysis, also used by Boxer, is based on evaluating the variation of an element from the mean point in terms of multiple of standard deviation. For the purpose of this work a slightly different approach is used but both will be explained. As an example, consider a 4×3 matrix, D

$$D=\begin{bmatrix}2 & 5 & 8\\ 3 & 7 & 11\\ 6 & 2 & 9\\ 4 & 3 & 2\end{bmatrix}.$$



$$D((1,2),(3,(4,5))) = 0{\cdot}8,$$

$$D(3,(4,5)) = \text{Ave}\,[D(3,4), D(3,5)],$$

$$\begin{aligned} D((1,2),(3,(4,5))) &= \text{Ave}[D(1,3), D(1,(4,5)), D(2,3), D(2,(4,5))], \\ &= \text{Ave}\,[D(1,3), D(1,4), D(1,5), D(2,3), D(2,4), D(2,5)]. \\ &= \text{Ave}\,[0{\cdot}6, 1, 0{\cdot}9, 0{\cdot}5, 0{\cdot}9, 0{\cdot}8] = 0{\cdot}8. \end{aligned}$$

FIG. 6. Dendrogram based on average distances.

The pattern matrix P would be

$$P = \begin{bmatrix} - & = & ++ \\ - & = & + \\ = & - & + \\ + & = & + \end{bmatrix},$$

where "=" signifies that the element is equal to the mean; "+(−)" signifies that the element is up to one standard deviation above (below) the mean; "++(−−)" signifies that the element is between one and two standard deviation above (below) the mean; "+++(−−−)" signifies that the element is more than two standard deviations above (below) the mean. This is the way that Boxer (1979) derives his pattern matrix. For our purpose, instead of measuring the variations about the mean value, the measurements will be about the value of the goal alternative or the ideal alternative which defines the decision maker's preference measures. This method of pattern creation enables the decision maker to see the relevant variations in options not about the mean value but about the ideal option which is of more interest to the multi-criteria decision maker.

3.3. LINGUISTIC LABELS

If required, the difference measures between options can be expressed by projecting a difference value on to an evaluative bipolar scale. The labelling process would not be as elaborate as the one used for fuzzy sets. It would be based on a comparison of the unknown value with the elements of a set of values pre-selected and distributed along the scale. The label of the nearest point to the unknown value would be taken to represent the difference measure. The dichiotomous pair of adjectives representing the difference value could be taken as *high–low* or *different–similar.* For example, option 1 and 2 can be said to be

INDEED VERY DIFFERENT.

4. An example

A job selection problem is considered. The main reason for choosing this problem is its highly subjective nature. The decision maker is offered a number of positions. Considering relevant criteria, he wishes to select the job most similar to his ideal one.

4.1. PROBLEM IDENTIFICATION

There are four jobs and a preference descriptor or goal job. Thus, the number of options is effectively five. As mentioned, criteria are defined or named together with their descriptive concepts, or the decision makers constructs. These constructs can be elicited by using a triad technique similar to that of Kelly's. A list of these criteria and the corresponding adjective pairs used for their description and evaluation of options is given in Fig. 7.

Criteria	Concept pairs	
	−ve	+ve
1. *SALARY*	*low*	*high*
2. *LOCATION*	*far*	*local*
3. *WORKING CONDITION*	*unhappy*	*happy*
4. *BOSS'S CHARACTER*	*unfriendly*	*friendly*
5. *COMPANY CAR*	*unlikely*	*likely*
6. *STATUS*	*low*	*high*
7. *PROMOTION PROSPECTS*	*gloomy*	*bright*
8. *TECHNICAL CONTENTS*	*basic*	*advance*
9. *MANAGERIAL CONTENTS*	*low*	*high*
10. *PENSION SCHEME*	*no*	*yes*
11. *HOLIDAYS*	*short*	*long*
12. *WORKING HOURS*	*rigid*	*flexible*
13. *OUTSIDE DUTIES*	*few*	*many*

FIG. 7. List of criteria and concepts.

There are a certain number of points worthy of mention. Using the technique described in this paper, one is enabled to involve highly subjective criteria, against which, evaluation of options in terms of *high* and *low* or a fixed set of predicates become impossible. *WORKING CONDITION* is a good example of a subjective criterion of this nature. Not only can it not be referred to using *low* and *high*, but it has to be related to a *relevant* pair of descriptive concepts. It is possible to describe *WORKING CONDITION* in terms of the concept pair *unhealthy–healthy* but this may be irrelevant. Other criteria which bring out this essential difference between CODEM2 and previously-reported work is significantly exemplified in 4 and 8 where concept pairs *friendly–unfriendly* and *bad–good* could have been used in a different context. The criteria *TECHNICAL CONTENTS* and *MANAGERIAL CONTENTS* are described using *qualitative* concept pair *basic–advance* and *quantitative* one *low–high*. Although both of these criteria appear to be of similar nature, they may, nevertheless, have to be described differently which would have not been possible in systems other than CODEM2.

Another interesting feature of CODEM2 is the possibility of bringing in criteria against which options have to be evaluated in a binary form. An example of this is the case in 11 where the existence of a *PENSION SCHEME* requires a binary answer *YES* or *NO*.

The names of the options and criteria are specified by using CODEM2's *NAME* commands. The unmarked or positive concept to be used when describing ratings are specified at the time of specifying the criteria names. The marked or negative concepts are only named when they are not to be formed by using the prefix *UN*. Otherwise each unmarked adjective is marked by using the prefix *UN* automatically.

The specification of concepts on a linear scale is optional. If this is not specified by the user, preselected values are used. In the case similar to the *PENSION SCHEME* criterion, the concept and null points are specified by placing *yes* at the extreme right-hand side of the scale and marking the null point in the middle which would ensure the position of *no* at the extreme left-hand side as shown below:

No	Null	Yes
0	0·5	1

Here a standard scale is used to define all adjective pairs except *yes–no* which is defined, as mentioned above, to establish the binary set-up. The complete decision matrix is shown in Fig. 8. The detailed interactive record for inputing this decision problem is given in the Appendix.

4.2. THE DECISION

Finally, the decision can be made on inspecting the difference groupings and studying the dendrogram produced. The difference table for options was obtained and is shown in Fig. 9.

It is quite clear, by inspecting the last row of the table in Fig. 9 that JOB3 and JOB1 are the most appropriate ones and the insentives in taking one over the other is minimal.

On the other hand, JOB2 seems to be the most unsuitable one of all. The dendrogram showing these features and others is shown in Fig. 10. It is evident from this dendrogram, that the closest alternative to the Ideal Job is JOB1 followed very closely by JOB3. JOB4 and JOB2 are very much alike and totally different from the Ideal Job and JOB1.

The preceding decision problem illustrates the following point. It may be argued that a best choice should be associated with *optimality* and not *ideality*. More specifically, instead of taking an *ideal alternative* as the reference measure, one should consider an *optimal one* which may even be permanently specified through a general concensus.

There is a clear distinction between these two cases. This is brought about as a result of subjective nature of a decision problem. In an *ideal alternative case*, ratings, descriptive of that alternative, are not necessarily optimal. This allows the decision maker to introduce some degree of preference and/or compromise. In the case of the

	JOB1	JOB2	JOB3	JOB4	IDEAL JOB
SALARY	*very high*	*very high*	*fairly high*	*fairly high*	*high*
LOCATION	*fairly local*	*fairly local*	*fairly local*	*far*	*not very far*
WORKING COND.	*happy*	*not very happy*	*happy*	*not happy and not sad*	*fairly happy*
BOSS'S CHARACTER	*not very kind*	*fairly unkind*	*kind*	*fairly unkind*	*kind*
COMPANY CAR	*very likely*	*very very unlikely*	*not unlikely*	*unlikely*	*very likely*
STATUS	*very high*	*very low*	*very high*	*high*	*not very low and not very high*
PROMOTION PROSPECTS	*not very bright*	*very gloomy*	*bright*	*fairly bright*	*bright*
TECHNICAL CONTENTS	*not very advance*	*very very basic*	*advance*	*very much advance*	*very advance*
MANAGERIAL CONTENTS	*very high*	*very low*	*fairly low*	*low*	*not very high*
PENSION SCHEME	*yes*	*no*	*yes*	*yes*	*yes*
HOLIDAYS	*very long*	*not long*	*fairly short*	*very long*	*very very long*
WORKING HOURS	*very flexible*	*very rigid*	*very flexible*	*not very fiexible*	*flexible*
OUTSIDE DUTIES	*many*	*very very few*	*not many*	*very few*	*not very many*

FIG. 8. Decision matrix.

criterion *LOCATION*, in this example, the fact that an ideal value (*not very far*) is chosen in preference to an optimal one (*very very local*) indicates that the individual may, despite general concensus, wish not to work in the locality that he lives. For example, he may wish to work in London because the pay is higher and live outside London because the rents are lower. Alternatively, the motivation may be one of *irrationality*, namely, the enjoyment of commuting.

Similarly, consider the criterion *MANAGERIAL CONTENTS* of a job where, because of its purely subjective nature, there is no way that a general optimal concensus can be arrived at. Thus, basically, there are two shortcomings associated with choosing an optimal alternative as the reference measure.

	JOB1	JOB2	JOB3	JOB4	IDEAL JOB
JOB1	0	48	19	31	17
JOB2	48	0	45	36	52
JOB3	19	45	0	23	19
JOB4	31	36	23	0	25
IDEAL JOB	17	52	19	25	0

FIG. 9. The difference table for the option.

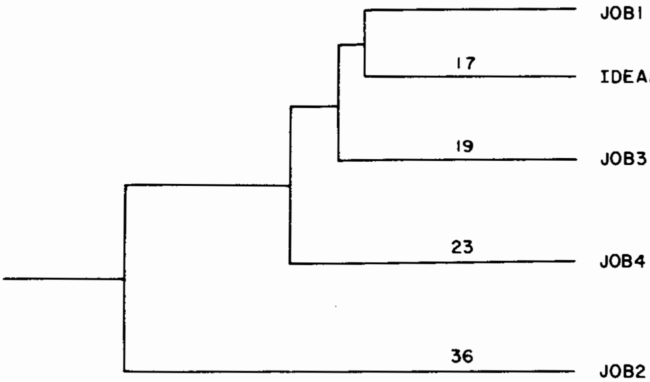


FIG. 10. Dendrogram for job selection problem.

(1) The individual's rating of the ideal option may not be in accordance with the rating relating to the optimum which may have been derived through a form of concensus, like in the case of criterion *LOCATION*.

(2) General consensus rating does not exist and hence no rating of the optimum is possible as in *MANAGERIAL CONTENTS* of a job where the only expression is that of the ideal.

Therefore, depending on the reference measure, different decisions may be arrived at. To illustrate this point, the job selection problem is considered with reference to both Ideal and Optimal ratings. Wherever possible, an optimal rating is assigned to a sixth alternative in terms of various criteria. In some cases, like *MANAGERIAL CONTENTS*, the optimal alternative is given the same value as that of an ideal one. A list of these ratings for the optimal alternative is given in Fig. 11. The dendrogram representing the similarities (Fig. 12), clearly indicates that the decision would be different depending on the reference measure. On the basis of similarity, if optimality

Criteria	Ratings for Optimal job
SALARY	*very very high*
LOCATION	*very very local*
WORKING CONDITIONS	*very very happy*
BOSS'S CHARACTER	*very very kind*
COMPANY CAR	*very very likely*
STATUS	*very very high*
PROMOTION PROSPECTS	*very very bright*
TECHNICAL CONTENTS	*very advance*†
MANAGERIAL CONTENTS	*high but not very high*†
PENSION SCHEME	*yes*
HOLIDAYS	*very very long*
WORKING HOURS	*very very flexible*
OUTSIDE DUTIES	*not very many*†

† The same rating as ideal option.

FIG. 11. Ratings for optimal job.

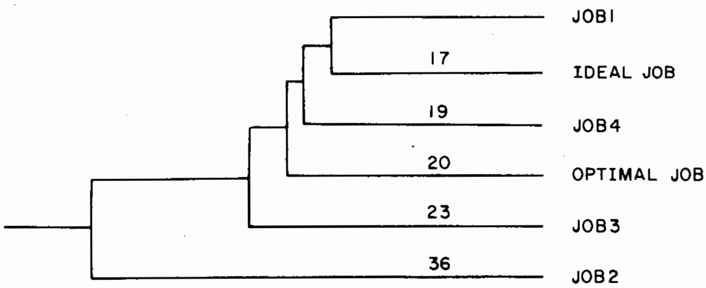


FIG. 12. Dendrogram for the job selection problem with both Ideal and Optimal alternatives.

criterion is used, JOB3 is the best alternative whereas, JOB1 would be selected if ideality is considered.

5. Conclusion

The message conveyed by the material presented in this paper emphasizes on the inevitable subjective nature of decision problems, where personal judgements and values play a significant role. There have been normative methods dealing with this kind of problem. Examples of these are the Repertory Grids (Fransella & Bannister, 1977; Boxer, 1970, and to some extent the material in Eshragh, 1979). A study of these works led to the development of a computer program called CODEM2. This program was developed using techniques of repertory grids based on the psychological theory of personal construct. There are certain advantages in using this method of problem solving. One of the major advantages is the fact that options or alternatives are no longer evaluated in terms of one adjective pair like *high–low*. Each criterion is given an adjective pair which defines the span of its applicability on a linear scale. Thus, it becomes possible to have evaluative criteria like *WORKING CONDITION* or *LOCATION* in a job selection problem. These are criteria which cannot be rated against in terms of a general purpose adjective pair like *high–low*.

Finally, a job selection problem was chosen for this paper. The reason for this was to show how extra criteria can be introduced into the decision space and establish the similarities and differences.

In the example above, an important issue was raised in connection with the specification of an ideal option against which given options were to be assessed in a multi-criteria decision problem.

It may be argued that the best choice of reference or desired option should be associated with *optimality* and not *ideality*. That is, instead of taking an ideal option as the reference measure, one should consider an optimal one which may even be permanently specified through a general concensus. The distinction between these two notions were discussed and it can be concluded that such distinction is brought about as a result of subjective nature of a decision problem. Thus, descriptions of options in an ideal manner may not necessarily be optimal in a subjective environment. As an example of this, one can look at the case where one is selecting a job and considering the job's managerial contents. Here, no standard optimal case exists as the desired amount of managerial contents of a job is purely subjective.

Acknowledgements

The author is indebted to Dr E. H. Mamdani under whose skilful supervision the author's doctoral thesis was produced and of which work reported in this paper is part.

References

ADAMS-WEBBER, J. & BENJAFIELD, J. (1976). The golden section hypothesis. *Br. J. Psychol.*, **67**(1), 11–15.

BAAS, S. M. & KWAKERNAAK, H. (1977). Rating and ranking of multiple-aspect alternatives using fuzzy sets. *Automatica*, **13**, 47–58.

BALDWIN, J. F. & GUILD, N. C. F. (1978). A model for multi-criteria decision making using fuzzy logic. University of Bristol, Mathematics Department, *Report EM/FS13*.

BANNISTER, D. & FRANSELLA, F. (1971). *Inquiring Man*. London: Penguin.

BOXER, P. (1979). Reflective analysis. *International Journal of Man–Machine Studies*, **11**(5), 547–584.

DEES, J. (1973). Cognitive structure and affect in language. In PALMER, P., KRAMES, L. & ALLOWAY, T., Eds. *Communication and Affect*. London: Academic Press.

EFSTATHIOU, J. (1979). A practical development of multi-attribute decision making using fuzzy set theory. Ph.D. thesis, Department of Computing, University of Durham.

ESHRAGH, F. (1979). Conversational programs for decision making using fuzzy set theory. Ph.D. thesis, Department of Electrical and Electronic Engineering, Queen Mary College, University of London.

ESHRAGH, F. & MAMDANI, E. H. (1979). A general approach to linguistic approximation. *International Journal of Man–Machine Studies*, **11**(4), 501–519.

EVERITT, B. (1974). *Cluster Analysis*. London: Heinemann.

FRANSELLA, F. & BANNISTER, D. (1977). *A Manual for Repertory Grid Technique*. London: Academic Press.

Appendix: Job selection problem using CODEM2

```
RU DK2:CODEM2

CODEM V02-79

>>>DIM ENSION,13,5


>>>NAME,OPTIONS

OPTION  1? JOB1

OPTION  2? JOB2

OPTION  3? JOB3

OPTION  4? JOB4

OPTION  5? IDEAL JOB


>>>NAME,CRITERIA

CRITERION  1? SALARY

CRITERION  2? LOCATION

CRITERION  3? WORKING COND.

CRITERION  4? BOSSES NATURE
```

```
CRITERION  5? COMPANY V\V\CAR

CRITERION  6? STATUS

CRITERION  7? PROMOTION PROS.

CRITERION  8? TECH. CONTENTS

CRITERION  9? MANAGERIAL CONT.

CRITERION 10? PENSION SCHEME

CRITERION 11? HOLIDAYS

CRITERION 12? WORKING HOURS

CRITERION 13? OUTSIDE DUTIED\D\S

SPECIFY THE POSITIVE ADJECTIVE WHICH YOU WOULD LIKE TO  USE WHEN RATING
IN TERMS OF SALARY            ? HIGH

IN TERMS OF LOCATION          ? LOCAL

IN TERMS OF WORKING COND.     ? HAPPY

IN TERMS OF BOSSES NATURE     ? KIND

IN TERMS OF COMPANY CAR       ? LIKELY

IN TERMS OF STATUS            ? HIGH

IN TERMS OF PROMOTION PROS.   ? BRIGHT

IN TERMS OF TECH. CONTENTS    ? ADVANCE

IN TERMS OF MANAGERIAL CONT   ? HIGH

IN TERMS OF PENSION SCHEME    ? YES

IN TERMS OF HOLIDAYS          ? LONG

IN TERMS OF WORKING HOURS     ? FLEXIBLKE

IN TERMS OF OUTSIDE DUTIES    ? MANY

ADJECTIVES ANTONYMS ARE FORMED BY USING THE PREFIX
"UN" - OTHERWISE USE THE COMMAND "NAME" TO SPECIFY

>>>NAME,ADJECTIVE,12

SPECIFY THE POSITIVE ADJECTIVE WHICH YOU WOULD LIKE TO  USE WHEN RATING
IN TERMS OF WORKING HOURS     ? FLEXIBLE

ADJECTIVES ANTONYMS ARE FORMED BY USING THE PREFIX
"UN" - OTHERWISE USE THE COMMAND "NAME" TO SPECIFY

>>>NAME,ANTONYM,SALARY

ANTONYM OF HIGH             ? LOW


>>>NAME,ANTONYM,LOCATION

ANTONYM OF LOCAL            ? FAR
```

```
>>>NAME,ANTONYM,WORKING COND.

ANTONYM OF HAPPY          ? SAD

>>>NAME,ANTONYM,STAR\R\TUS

ANTONYM OF HIGH           ? LOW

>>>NAME,ANTONYM,BRIGHT

ANTONYM OF BRIGHT         ? GLOOMY

>>>NAME,ANTONYM,ADVANCE

ANTONYM OF HIGH           ? ##

>>>NAME,ANTONYM,CRITERION,9

ANTONYM OF HIGH           ? LOW

>>>NAME,ANTONYM,CRITERION,8

ANTONYM OF ADVANCE        ? BASIC

>>>NAME,ANTONYM,TECH. CONTENTS

ANTONYM OF ADVANCE        ? BASIC

>>>NAME,ANTONYM,YES

ANTONYM OF YES            ? NO

>>>NAME,ANTONYME,LONG

ANTONYM OF LONG           ? SHORT

>>>NAME,ANTONYM,FLEXIBLE

ANTONYM OF FLEXIBLE       ? RIGID

>>>NAME;ANTONU\U\YM,MANY

ANTONYM OF MANY           ? FEW

>>>LIST,CRITERIA

CONCEPTS         +VE ADJECTIVE    -VE ADJECTIVE

SALARY          /HIGH            /LOW             / 15 40 75/
LOCATION        /LOCAL           /FAR             / 15 40 75/
WORKING COND.   /HAPPY           /SAD             / 15 40 75/
BOSSES NATURE   /KIND            /UNKIND          / 15 40 75/
COMPANY CAR     /LIKELY          /UNLIKELY        / 15 40 75/
STATUS          /HIGH            /LOW             / 15 40 75/
PROMOTION PROS./BRIGHT           /GLOOMY          / 15 40 75/
```

```
TECH. CONTENTS /ADVANCE         /BASIC           / 15 40 75/
MANAGERIAL CONT/HIGH            /LOW             / 15 40 75/
PENSION SCHEME /YES             /NO              / 15 40 75/
HOLIDAYS       /LONG            /SHORT           / 15 40 75/
WORKING HOURS  /FLEXIBLE        /RIGID           / 15 40 75/
OUTSIDE DUTIES /MANY            /FEW             / 15 40 75/

>>>SCALE,PENSION SCHEME

MARK ON THE SCALE THE NEUTRAL & +VE ADJECTIVE POINTS

         TYPE "0" FOR "THE NEUTRAL POINT"
         TYPE "1" FOR   "THE +VE ADJ."


MARK FOR PENSION SCHEME

LOW                                                HIGH
------------------------0------------------------1


>>>LIST,CRITERIA

CONCEPTS        +VE ADJECTIVE   -VE ADJECTIVE

SALARY         /HIGH            /LOW             / 15 40 75/
LOCATION       /LOCAL           /FAR             / 15 40 75/
WORKING COND.  /HAPPY           /SAD             / 15 40 75/
BOSSES NATURE  /KIND            /UNKIND          / 15 40 75/
COMPANY CAR    /LIKELY          /UNLIKELY        / 15 40 75/
STATUS         /HIGH            /LOW             / 15 40 75/
PROMOTION PROS./BRIGHT          /GLOOMY          / 15 40 75/
TECH. CONTENTS /ADVANCE         /BASIC           / 15 40 75/
MANAGERIAL CONT/HIGH            /LOW             / 15 40 75/
PENSION SCHEME /YES             /NO              /  0 49 99/
HOLIDAYS       /LONG            /SHORT           / 15 40 75/
WORKING HOURS  /FLEXIBLE        /RIGID           / 15 40 75/
OUTSIDE DUTIES /MANY            /FEW             / 15 40 75/

>>>RATE

YOUR RATING AGAINST SALARY
IN TERMS OF HIGH
AND LOW
FOR JOB1            ? VERY HIGH

HIGH^S^Q    .....NOT IN THE VOCABULARY

FOR JOB1            ? VERY HIGH

FOR JOB2            ? VERY HIGH

FOR JOB3            ? FAIRLY HIGH

FOR JOB4            ? FAIRK\K\LY HIGH

FOR IDEAL JOB       ? HIGH

YOUR RATING AGAINST LOCATION
IN TERMS OF LOCAL
AND FAR
FOR JOB1            ? FAIRLY LOCAL

FOR JOB2            ? FAIRLY LOCAL

FOR JOB3            ? FAIRLY LOCAL
```

```
FOR JOB4             ? FAR

FOR IDEAL JOB        ? NOT VERY FAR

YOUR RATING AGAINST WORKING COND.
IN TERMS OF HAPPY
AND SAD
FOR JOB1             ? HAPPY

FOR JOB2             ? NOT VERY HAPPY

FOR JOB3             ? HAPPY

FOR JOB4             ? NOT HAPPY AND NOT SAD

FOR IDEAL JOB        ? FAIRLY HAPPY

YOUR RATING AGAINST BOSSES NATURE
IN TERMS OF KIND
AND UNKIND
FOR JOB1             ? NOT VERY KIND

FOR JOB2             ? FAIRLY UNKIND

FOR JOB3             ? KIND

FOR JOB4             ? FAIRLY UNKIND

FOR IDEAL JOB        ? KIND

YOUR RATING AGAINST COMPANY CAR
IN TERMS OF LIKELY
AND UNLIKELY
FOR JOB1             ? VERY LIKELY

FOR JOB2             ? QUITE UNLIKELY

QUITE     .....NOT IN THE VOCABULARY

FOR JOB2             ? HEDGE

NOT
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BELOW
BELO
AND
BUT
OR
(
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```

```
FOR JOB2             ? VERY MUCH UNLIKELY

FOR JOB3             ? NOT UNLIKELY

FOR JOB4             ? UNLIKELY

FOR IDEAL JOB        ? VERY LIKELY

YOUR RATING AGAINST STATUS
IN TERMS OF HIGH
AND LOW
FOR JOB1             ? HIGH

FOR JOB2             ? VERY LOW

FOR JOB3             ? VERY HIGH

FOR JOB4             ? HIGH

FOR IDEAL JOB        ? HIGH BUT NOT VERY HIGH

YOUR RATING AGAINST PROMOTION PROS.
IN TERMS OF BRIGHT
AND GLOOMY
FOR JOB1             ? NOT VERY BRIGHT

FOR JOB2             ? VERY GLOOMY

FOR JOB3             ? BRIGHT

FOR JOB4             ? FAIRLY BRIGHT

FOR IDEAL JOB        ? BRIGHT

YOUR RATING AGAINST TECH. CONTENTS
IN TERMS OF ADVANCE
AND BASIC
FOR JOB1             ? NOT VERY ADVANCE

FOR JOB2             ? VERY VERY BASIC

FOR JOB3             ? ADVANCE

FOR JOB4             ? VERY MUCH ADVANCE

FOR IDEAL JOB        ? VERY ADVANCE

YOUR RATING AGAINST MANAGERIAL CONT
IN TERMS OF HIGH
AND LOW
FOR JOB1             ? VERY HIGH

FOR JOB2             ? VERY LOW

FOR JOB3             ? FAIRLY LOW

FOR JOB4             ? LOW

FOR IDEAL JOB        ? NOT VERY HIGH

YOUR RATING AGAINST PENSION SCHEME
IN TERMS OF YES
AND NO
FOR JOB1             ? YES

FOR JOB2             ? NO
```

```
FOR JOB3            ? YES

FOR JOB4            ? YES

FOR IDEAL JOB       ? YES

YOUR RATING AGAINST HOLIDAYS
IN TERMS OF LONG
AND SHORT
FOR JOB1            ? FAIRLY LONG

FOR JOB2            ? LONG

FOR JOB3            ? VERY LONG

FOR JOB4            ? FAIRLY LONG

FOR IDEAL JOB       ? NOT VERY SHORT

YOUR RATING AGAINST WORKING HOURS
IN TERMS OF FLEXIBLE
AND RIGID
FOR JOB1            ? VERY FLEXIBLE

FOR JOB2            ? VERY RIGID

FOR JOB3            ? VERY FLEXIBLE

FOR JOB4            ? NOT VERY FLEXIBLE

FOR IDEAL JOB       ? FLEXIBLE

YOUR RATING AGAINST OUTSIDE DUTIES
IN TERMS OF MANY
AND FEW
FOR JOB1            ? MANY

FOR JOB2            ? VERY VERY FEW

FOR JOB3            ? VERY FEW

FOR JOB4            ? NOT VERY MANY

FOR IDEAL JOB       ? MANY


>>>LIST,RATE,OUTSIDE DUTIES

RATINGS AGAINST OUTSIDE DUTIES
FOR JOB1           :- MANY                               74
FOR JOB2           :- VERY VERY FEW                       4
FOR JOB3           :- VERY FEW                            8
FOR JOB4           :- NOT VERY MANY                      54
FOR IDEAL JOB      :- MANY                               74

>>>RATE,OUTSIDE DUTIES

YOUR RATING AGAINST OUTSIDE DUTIES
IN TERMS OF MANY
AND FEW
FOR JOB1            ? MANY

FOR JOB2            ? VERY FEW\WEF\VERY FEW

FOR JOB3            ? NOT MANY
```

```
FOR JOB4             ? VERY FEW

FOR IDEAL JOB        ? NOT VERY MANY


>>>LIST,RATE,OPTIONS

LIMITS EXCEEDED

>>>LIST,RATES,OPTION,1

RATING FOR JOB1
IN TERMS OF SALARY            :- VERY HIGH
IN TERMS OF LOCATION          :- FAIRLY LOCAL
IN TERMS OF WORKING COND.     :- HAPPY
IN TERMS OF BOSSES NATURE     :- NOT VERY KIND
IN TERMS OF COMPANY CAR       :- VERY LIKELY
IN TERMS OF STATUS            :- HIGH
IN TERMS OF PROMOTION PROS.:- NOT VERY BRIGHT
IN TERMS OF TECH. CONTENTS :- NOT VERY ADVANCE
IN TERMS OF MANAGERIAL CONT:- VERY HIGH
IN TERMS OF PENSION SCHEME :- YES
IN TERMS OF HOLIDAYS          :- FAIRLY LONG
IN TERMS OF WORKING HOURS     :- VERY FLEXIBLE
IN TERMS OF OUTSIDE DUTIES :- MANY

>>>LIST,RATE,OPTION,2

RATING FOR JOB2
IN TERMS OF SALARY            :- VERY HIGH
IN TERMS OF LOCATION          :- FAIRLY LOCAL
IN TERMS OF WORKING COND.     :- NOT VERY HAPPY
IN TERMS OF BOSSES NATURE     :- FAIRLY UNKIND
IN TERMS OF COMPANY CAR       :- VERY MUCH UNLIKELY
IN TERMS OF STATUS            :- VERY LOW
IN TERMS OF PROMOTION PROS.:- VERY GLOOMY
IN TERMS OF TECH. CONTENTS :- VERY VERY BASIC
IN TERMS OF MANAGERIAL CONT:- VERY LOW
IN TERMS OF PENSION SCHEME :- NO
IN TERMS OF HOLIDAYS          :- LONG
IN TERMS OF WORKING HOURS     :- VERY RIGID
IN TERMS OF OUTSIDE DUTIES :- VERY VERY FEW

>>>LIST,RATE,OPTION,3

RATING FOR JOB3
IN TERMS OF SALARY            :- FAIRLY HIGH
IN TERMS OF LOCATION          :- FAIRLY LOCAL
IN TERMS OF WORKING COND.     :- HAPPY
IN TERMS OF BOSSES NATURE     :- KIND
IN TERMS OF COMPANY CAR       :- NOT UNLIKELY
IN TERMS OF STATUS            :- VERY HIGH
IN TERMS OF PROMOTION PROS.:- BRIGHT
IN TERMS OF TECH. CONTENTS :- ADVANCE
IN TERMS OF MANAGERIAL CONT:- FAIRLY LOW
IN TERMS OF PENSION SCHEME :- YES
IN TERMS OF HOLIDAYS          :- VERY LONG
IN TERMS OF WORKING HOURS     :- VERY FLEXIBLE
IN TERMS OF OUTSIDE DUTIES :- NOT MANY

>>>LIST,RATE,OPTION,4

RATING FOR JOB4
IN TERMS OF SALARY            :- FAIRLY HIGH
IN TERMS OF LOCATION          :- FAR
IN TERMS OF WORKING COND.     :- NOT HAPPY AND NOT SAD
```

```
IN TERMS OF BOSSES NATURE   :- FAIRLY UNKIND
IN TERMS OF COMPANY CAR     :- UNLIKELY
IN TERMS OF STATUS          :- HIGH
IN TERMS OF PROMOTION PROS.:- FAIRLY BRIGHT
IN TERMS OF TECH. CONTENTS :- VERY MUCH ADVANCE
IN TERMS OF MANAGERIAL CONT:- LOW
IN TERMS OF PENSION SCHEME :- YES
IN TERMS OF HOLIDAYS        :- FAIRLY LONG
IN TERMS OF WORKING HOURS   :- NOT VERY FLEXIBLE
IN TERMS OF OUTSIDE DUTIES :- VERY FEW

>>>LIST,RATE,OPTION,5

RATING FOR IDEAL JOB
IN TERMS OF SALARY          :- HIGH
IN TERMS OF LOCATION        :- NOT VERY FAR
IN TERMS OF WORKING COND.   :- FAIRLY HAPPY
IN TERMS OF BOSSES NATURE   :- KIND
IN TERMS OF COMPANY CAR     :- VERY LIKELY
IN TERMS OF STATUS          :- HIGH BUT NOT VERY HIGH
IN TERMS OF PROMOTION PROS.:- BRIGHT
IN TERMS OF TECH. CONTENTS :- VERY ADVANCE
IN TERMS OF MANAGERIAL CONT:- NOT VERY HIGH
IN TERMS OF PENSION SCHEME :- YES
IN TERMS OF HOLIDAYS        :- NOT VERY SHORT
IN TERMS OF WORKING HOURS   :- FLEXIBLE
IN TERMS OF OUTSIDE DUTIES :- NOT VERY MANY

>>>LIST,RELATION

          OPTIONS
     1  2  3  4  5
 1  85 85 59 59 74  SALARY
 2  59 59 59 15 31  LOCATION
 3  74 54 74 40 59  WORKING COND.
 4  54 24 74 24 74  BOSSES NATURE
 5  85  4 24 15 85  COMPANY CAR
 6  74  8 85 74 64  STATUS
 7  54  8 74 59 74  PROMOTION PROS.
 8  54  4 74 92 85  TECH. CONTENTS
 9  85  8 24 15 54  MANAGERIAL CONT.
10  98  0 98 98 98  PENSION SCHEME
11  59 74 85 59 31  HOLIDAYS
12  85  8 85 54 74  WORKING HOURS
13  74  4 65  8 54  OUTSIDE DUTIES


OPTIONS ARE:

JOB1
JOB2
JOB3
JOB4
IDEAL JOB

>>>COMPARE,OPTIONS

OPTIONS COMPARISON TABLE

          1  2  3  4  5
     1   -- 48 19 31 17
     2   -- -- 45 36 52
     3   -- -- -- 23 19
     4   -- -- -- -- 25
     5   -- -- -- -- --
OPTIONS ARE:
```

JOB1
JOB2
JOB3
JOB4
IDEAL JOB

>>>COMPARE,CRITERIA

CRITERIA COMPARISON TABLE

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	--	27	18	28	19	27	24	34	35	40	21	21	33
2	--	--	17	21	29	36	31	41	27	57	17	37	20
3	--	--	--	16	30	19	20	29	27	39	18	19	18
4	--	--	--	--	33	21	10	19	25	38	28	17	16
5	--	--	--	--	--	47	44	49	23	55	40	39	34
6	--	--	--	--	--	--	11	14	26	20	25	8	19
7	--	--	--	--	--	--	--	9	29	27	25	9	20
8	--	--	--	--	--	--	--	--	38	18	34	19	29
9	--	--	--	--	--	--	--	--	--	44	44	24	11
10	--	--	--	--	--	--	--	--	--	--	46	20	39
11	--	--	--	--	--	--	--	--	--	--	--	28	35
12	--	--	--	--	--	--	--	--	--	--	--	--	19
13	--	--	--	--	--	--	--	--	--	--	--	--	--

CONCEPTS	+VE ADJECTIVE	-VE ADJECTIVE	
SALARY	/HIGH	/LOW	/ 15 40 75/
LOCATION	/LOCAL	/FAR	/ 15 40 75/
WORKING COND.	/HAPPY	/SAD	/ 15 40 75/
BOSSES NATURE	/KIND	/UNKIND	/ 15 40 75/
COMPANY CAR	/LIKELY	/UNLIKELY	/ 15 40 75/
STATUS	/HIGH	/LOW	/ 15 40 75/
PROMOTION PROS.	/BRIGHT	/GLOOMY	/ 15 40 75/
TECH. CONTENTS	/ADVANCE	/BASIC	/ 15 40 75/
MANAGERIAL CONT	/HIGH	/LOW	/ 15 40 75/
PENSION SCHEME	/YES	/NO	/ 0 49 99/
HOLIDAYS	/LONG	/SHORT	/ 15 40 75/
WORKING HOURS	/FLEXIBLE	/RIGID	/ 15 40 75/
OUTSIDE DUTIES	/MANY	/FEW	/ 15 40 75/

>>>LIST,RELATION

	OPTIONS					
	1	2	3	4	5	
1	85	85	59	59	74	SALARY
2	59	59	59	15	31	LOCATION
3	74	54	74	40	59	WORKING COND.
4	54	24	74	24	74	BOSSES NATURE
5	85	4	24	15	85	COMPANY CAR
6	74	8	85	74	64	STATUS
7	54	8	74	59	74	PROMOTION PROS.
8	54	4	74	92	85	TECH. CONTENTS
9	85	8	24	15	54	MANAGERIAL CONT
10	98	0	98	98	98	PENSION SCHEME
11	59	74	85	59	31	HOLIDAYS
12	85	8	85	54	74	WORKING HOURS
13	74	4	65	8	54	OUTSIDE DUTIES

OPTIONS ARE:

JOB1
JOB2
JOB3
JOB4
IDEAL JOB

OPTIONS

	1	2	3	4	5	6	
1	85	85	59	59	74	92	SALARY
2	59	59	59	15	31	92	LOCATION
3	74	54	74	40	59	92	WORKING COND.
4	54	24	74	24	74	92	BOSSES NATURE
5	85	4	24	15	85	92	COMPANY CAR
6	74	8	85	74	64	92	STATUS
7	54	8	74	59	74	92	PROMOTION PROS.
8	54	4	74	92	85	85	TECH. CONTENTS
9	85	8	24	15	54	54	MANAGERIAL CONT
10	98	0	98	98	98	98	PENSION SCHEME
11	59	74	85	59	31	92	HOLIDAYS
12	85	8	85	54	74	92	WORKING HOURS
13	74	4	65	8	54	54	OUTSIDE DUTIES

OPTIONS ARE:

JOB1
JOB2
JOB3
JOB4
IDEAL JOB
OPTIMAL JOB

>>>COMPARE,OPTIONS

OPTIONS COMPARISON TABLE

	1	2	3	4	5	6
1	--	48	19	31	17	21
2	--	--	45	36	52	59
3	--	--	--	23	19	20
4	--	--	--	--	25	40
5	--	--	--	--	--	20
6	--	--	--	--	--	--

OPTIONS ARE:

JOB1
JOB2
JOB3
JOB4
IDEAL JOB
OPTIMAL JOB

>>>

CRITERIA COMPARISON TABLE

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	--	23	15	23	28	23	20	29	35	34	17	18	34
2	--	--	14	17	28	30	26	35	28	48	14	30	24
3	--	--	--	13	27	16	16	25	29	34	15	16	22
4	--	--	--	--	20	17	8	17	27	32	24	14	20
5	--	--	--	--	--	26	23	27	12	32	42	19	21
6	--	--	--	--	--	--	9	13	29	18	21	6	23
7	--	--	--	--	--	--	--	9	30	24	20	7	23
8	--	--	--	--	--	--	--	--	37	17	30	17	29
9	--	--	--	--	--	--	--	--	--	44	43	26	10
10	--	--	--	--	--	--	--	--	--	--	39	18	39
11	--	--	--	--	--	--	--	--	--	--	--	23	36
12	--	--	--	--	--	--	--	--	--	--	--	--	23
13	--	--	--	--	--	--	--	--	--	--	--	--	--

```
CONCEPTS           +VE ADJECTIVE    -VE ADJECTIVE

SALARY            /HIGH            /LOW                / 15 40 75/
LOCATION          /LOCAL           /FAR                / 15 40 75/
WORKING COND.     /HAPPY           /SAD                / 15 40 75/
BOSSES NATURE     /KIND            /UNKIND             / 15 40 75/
COMPANY CAR       /LIKELY          /UNLIKELY           / 15 40 75/
STATUS            /HIGH            /LOW                / 15 40 75/
PROMOTION PROS./BRIGHT             /GLOOMY             / 15 40 75/
TECH. CONTENTS /ADVANCE            /BASIC              / 15 40 75/
MANAGERIAL CONT/HIGH               /LOW                / 15 40 75/
PENSION SCHEME /YES                /NO                 /  0 49 99/
HOLIDAYS          /LONG            /SHORT              / 15 40 75/
WORKING HOURS  /FLEXIBLE           /RIGID              / 15 40 75/
OUTSIDE DUTIES /MANY               /FEW                / 15 40 75/

>>>LI,RE

          OPTIONS
      1  2  3  4  5  6
 1   85 85 59 59 74 92  SALARY
 2   59 59 59 15 31 92  LOCATION
 3   74 54 74 40 59 92  WORKING COND.
 4   54 24 74 24 74 92  BOSSES NATURE
 5   85  4 24 15 85 92  COMPANY CAR
 6   74  8 85 74 64 92  STATUS
 7   54  8 74 59 74 92  PROMOTION PROS.
 8   54  4 74 92 85 85  TECH. CONTENTS
 9   85  8 24 15 54 54  MANAGERIAL CONT
10   98  0 98 98 98 98  PENSION SCHEME
11   59 74 85 59 31 92  HOLIDAYS
12   85  8 85 54 74 92  WORKING HOURS
13   74  4 65  8 54 54  OUTSIDE DUTIES

OPTIONS ARE:

JOB1
JOB2
JOB3
JOB4
IDEAL JOB
OPTIMAL JOB

>>>
```

A statistical aid for the grid administrator

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In this paper the authors consider the problem of obtaining statistical information about a repertory grid during its elicitation. A measure of cognitive complexity, element intraclass correlation, provides the administrator of the grid with information about the change in the respondent's cognitive complexity as each additional construct is elicited and scored on the element sample. The approach is illustrated with *post hoc* analyses of 20 grids and shows the benefit of having such information available during the process of elicitation.

Introduction

The repertory grid technique has proved to be a useful tool in eliciting the constructs a person uses in relating the elements of his world. This usefulness, however, has only become apparent with the advent of computer analyses of grid data. A grid consists of a series of responses by the person, one for each element with respect to each construct. The aim of grid analysis is to show the relationships among constructs and elements which have resulted in the responses made, and there have been two major approaches to this analysis. One has been the use of clustering algorithms, such as the approach of Shaw & Thomas (1978); and the other, a singular-value decomposition or "principal components" approach epitomised in the work of Slater (1977). While there has been some discussion of these different approaches, e.g. Fransella & Bannister (1977), and indeed some empirical comparison (Rathod, 1980); it is not yet clear how the different analyses might produce methodological artefacts, or how the methods might react to abnormalities in the data. With respect to the last issue, namely data abnormalities, there has been little a clinician could do (until recently) as these would only be detected (if at all) during the analysis which was conducted after the grid had been completely elicited.

Within the clustering approach, Shaw (1980) has described an interactive program PEGASUS, which is accessible to the clinician being simple enough to be programmed for microcomputer. In this paper we propose a simple technique which relates to the alternative tradition of principal components, and has a ready interpretation in terms of repertory grid theory. The intraclass correlation among elements can be easily computed (by a small computer) as each construct is elicited, and may be said to provide a measure of cognitive complexity at that stage of elicitation.

The notion of cognitive complexity may be said to have originated with Bieri (1955) who defined it in the following way:

> A system of constructs which differentiate highly among persons is said to be cognitively complex. A construct system which provides poor differentiation among persons is considered to be cognitively simple in structure.

Although, 11 years later, Bieri (1966) redefined the concept as:

> Cognitive complexity may be defined as the tendency to construe social behaviour in a multi-dimensional way, such that a more cognitively complex individual has available a more versatile system for perceiving the behaviour of others than does a less cognitively complex person.

We would see the element intraclass correlation operationalizing the earlier definition in the broader sense of applying to any elements rather than just persons.

There has been substantial interest in this idea for some time and measures of Intensity of construct relationship have been developed, e.g. Bannister (1960, 1962) and used in a number of studies, e.g. Warren (1966) and Mair (1964). Bannister considered that high Intensity score might indicate a high degree of organization in the area of the subject's component space being investigated, and thereby represent what Kelly termed "tight" construing. Low Intensity, he hypothesized, might indicate a relative lack of clear-cut conceptual structure. Bonarius (1965), Adams-Webber (1969, 1970) and Landfield (1971) have all considered the concept of cognitive complexity, but a review of this literature provides a less than clear picture of what could be called a definition of the term, indeed measures purporting to be of "cognitive complexity" show amazing differences in nature. In an attempt to clarify the position, Vannoy (1965) produced evidence suggesting that the concept of cognitive complexity is in itself multi-dimensional, and that all the different indices measured different aspects of it.

Metcalfe (1974) has argued that Bieri's (1955) definition, and thus our measure, is a measure of "cognitive differentiation"; however, we do not propose engaging in this argument of semantics here, rather we claim that our measure can be a useful summary index that can be used in decision making during the elicitation of a grid. For example, in grid elicitation one needs to know when to stop eliciting constructs. Any researcher who has used a repertory grid based methodology will have experienced this dilemma at some stage. Respondents vary from those who seem to be able to provide an endless stream of constructs, all claimed to be independent (until subsequently proved otherwise in analysis) while others find extreme difficulty in progressing beyond nine or so.

Cognitive complexity, like other grid measures, depends on the constructs elicited. Not only the quality (range of convenience, etc.) but also the quantity. The cognitive complexity of a 2 construct elicitation is likely to be less than the complexity of a 12 construct elicitation.

Thus, we may look at the change in our measure of cognitive complexity as each construct is added to the system, and if normal grids provide element intraclass correlations which vary as the hypothetical curve in Fig. 1, then this index might be included in the information used to decide when to stop eliciting grids. Other critical behaviours should also show up in the variation of the index as constructs are added, and some discussion of these is given later where illustrative grids are considered.

A measure of cognitive complexity

The measure we propose relates to the general linear model proposed for grid data by Gower (1977):

$$Y_{ij} = \mu + \alpha_i + \beta_j + (\gamma_i \gamma_j' + \text{error}),$$

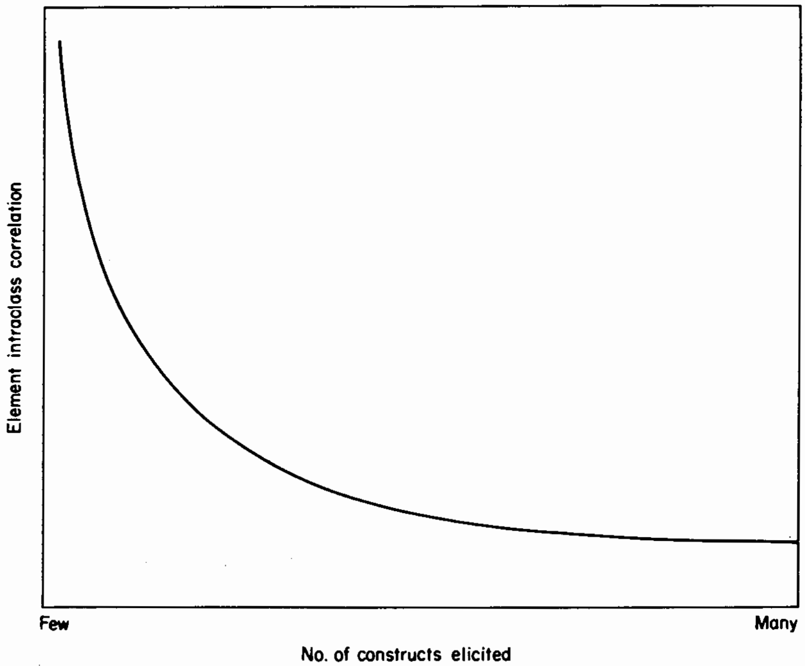

FIG. 1. Hypothetical relationship between no. of constructs and element intraclass correlation in grid elicitation.

where Y_{ij} is the number assigned to element i (among m) for construct j (among n), μ is the grand mean effect, α is the vector of element effects, β is the vector of construct effects and $\gamma\gamma'$ is the matrix of interaction effects.

With some assumptions (namely that each vector sums to zero) least-squares estimates may be made of the element and construct effects thus:

$$a_i = y_{i\cdot} - y_{\cdot\cdot},$$

$$b_j = y_{\cdot j} - y_{\cdot\cdot},$$

and

$$z_{ij} = y_{ij} - y_{i.} - y_{.j} + y_{..}.$$

This is in fact a simple two-way ANOVA of a grid. The matrix containing z_{ij} (the remainder in ANOVA terms) is amenable to decomposition into multiplicative terms (see Gower, 1977) where each term corresponds to a latent root of the matrix $Z'Z$. Associated with the sum of squares $a_{i.}$, $b_{.j}$ and z_{ij}, are degrees of freedom, and thus we may compute ordinary mean squares. From these mean squares (or variance estimates) it is possible to compute an intraclass correlation, R_{ic}, where

$$R_{ic} = \frac{\mathrm{MS}_c - \mathrm{MS}_r}{\mathrm{MS}_c + (m-1)\mathrm{MS}_r},$$

where MS_c is the mean squares between constructs and MS_r is the remainder mean squares.

TABLE 1

Table of intraclass correlations for elements of a grid as each successive construct is added

	No. of constructs																		
Subject	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
3027	021	010	016	003	014	026	041	034	028	030	025	022	033	035	038	039	032	040	045
3026	−045	−006	004	−011	020	015	022	017	014	013	004								
3024	−029	−032	−036	−038	−032	−043	−043	−047	−041	−037	−001								
3023	−071	−056	−059	−061	−038	−031	−037	−012	−002										
3021	099	053	027	048	026	033	071	057	057	061	060								
2009	−062	−055	−035	−030	−034	022	011	004	−001	−003	007	008	002	000	003				
2010	−017	−027	067	053	044	049	045	026	031	025	013								
2011	348	266	268	234	219	207	180	246	230	219	205	194	212	247	246	255	251	253	248
2017	284	195	120	088	079	086	062	091	094	089	099	094	085						
2013	148	151	113	076	067	073	064	073	065	062	055								
2006	459	376	296	261	196	204	192	166	162	157	130								
2008	548	111	096	074	050	048	078	074	068	066	059								
2015	328	014	037	018	088	094	113	121	102	150	133								
2012	229	146	122	091	083	066	060	077	068	154	137								
2018	076	084	100	041	039	037	026	032	075	078	123	120	115	111	107	109	107	118	112
2019	−037	−010	−018	−026	−032	−034	−028	−031	−037	155	140	127	118						
2020	−075	−033	122	161	193	194	156	145	126	108	112								
3022	000	071	063	351	318	304	267	228	219	200	198								
2007	040	011	009	008	152	127	108	099	115	106	086								
2016	−016	097	049	104	070	057	105	103	081	071	074								

This intraclass correlation is in fact equivalent to the average intercorrelation among the elements. If a high correlation results, then the elements are similar (according to the constructs elicited) and if a low correlation is obtained then the elements are differentiated by the constructs.

As mentioned above, this index relates to the principal components approach, and in fact the remainder mean squares (MS_r) is equivalent to the latent roots of a principal components analysis. The size of the first latent root has often been taken as an index of cognitive complexity, although this will depend in part on the removal of element and construct effects.

Results

The ideas postulated here were tested on a random sample of data selected from some 200 grids elicited by one of the authors (Keen, 1979). Twenty grids were selected thus with a common element sample. Table 1 lists the grid reference numbers and the element intraclass correlations.

Discussion

The respondents could be seen to fall into four categories. Forty per cent had consistent values for element intraclass correlation, and for those respondents the authors would feel that the original elicitation procedures had not continued for long enough, or in other terms the elicitation of further constructs would have been a worthwhile exercise.

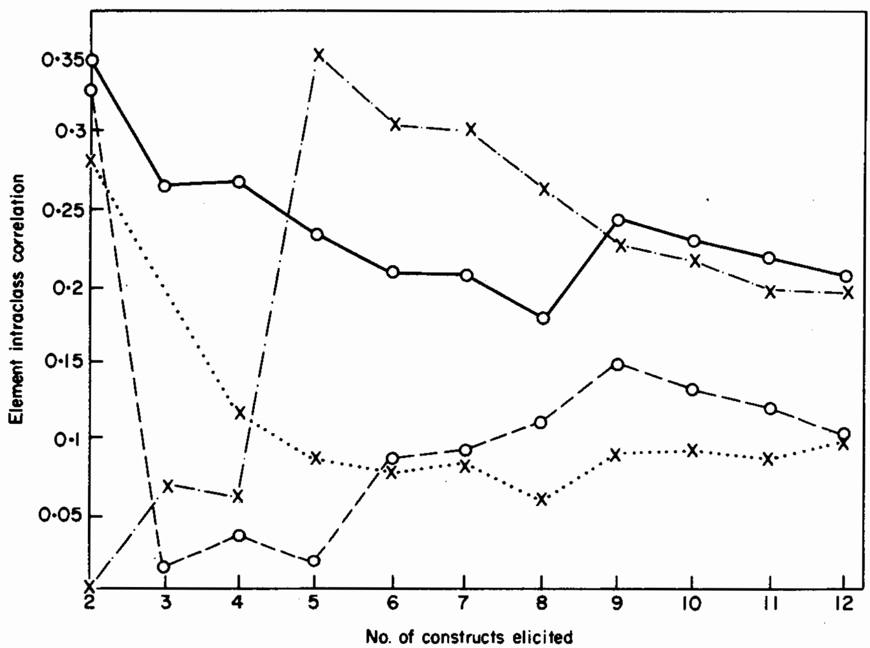

FIG. 2. Relationships between no. of constructs elicited and element interclass correlation for a selection of grids.

Figure 2 gives a graphical representation of a typical response from this category (the solid line).

Twenty per cent of the sample followed the hypothesized curve and it is suggested that elicitation of further constructs would have produced no additional information, and indeed the elicitation could well have ceased earlier (say after construct 8 in the example of Fig. 2) with no real difference emerging from the re-analysis of the grid. The dotted line of Fig. 2 is typical of this set of respondents. It is the remaining two categories which, accounting for 40% of all the respondents, provide interesting, and perhaps surprising, results. The first of these two categories we call "High–low–High". The broken line of Fig. 2 is typical and a decline akin to that hypothesized is followed by a "second breath" type of rise. We would hesitate to suggest causes, but are confident that ceasing elicitation of constructs at a time when the element intraclass correlation is rising is almost certainly depriving the researcher of additional worthwhile data, even although the client might be adamant that he has exhausted his repertoire of constructs. Whilst one is hesitant to make generalizations from such a small data producing sample, there is no evidence from our data to suggest that resurgent rise in element intraclass correlation will occur after the eighth or ninth construct has been elicited. Thus it might be possible to cease elicitation when three successive element intraclass correlation do not change significantly if and only if a minimum of eight constructs had been elicited at that time.

The final category, represented by the dot–dashed line of Fig. 2, has been termed the "Low–high–Low" group. Here the hypothesized curve is followed only after an initial rise from zero, suggesting that some time was spent eliciting undiscriminating constructs (3–5 constructs) before the constructs elicited began to effectively differentiate among the elements. Such data as this would have been invaluable during the elicitation process, to enable the researcher to guide and assist the respondent.

Conclusions

The enormous range of uses to which grids have been put in the last decade has resulted in the evolution of a wide range of techniques for elicitation. The advent of the microprocessor has facilitated the analysis in order to provide immediate feedback for the administrator and client. Notwithstanding these developments, there have been a number of problems largely ignored and the proper time to stop eliciting constructs is one such area. Some techniques allow the respondent to add constructs and/or elements throughout the elicitation process but even for such techniques the finishing time is frequently determined only by some casual observation of the administrator or when the client appears to have "dried up", or run out of his expressed repertoire of constructs.

The authors, in their attempt to develop a new interactive computer program wished to relieve the client of the decision of when to stop, or, at the very least, build into the program the kinds of "prompts" regarding ceasing elicitation which an experienced clinician familiar with grid elicitation procedures might use.

Element intraclass correlation looked promising as an indicator of when elicitation of further constructs might not yield worthwhile additional data.

Having looked at the results with respect to the original analysis, it is clear that the final conclusions drawn from a grid analysis will not be significantly different if construct elicitation is ceased when three successive values of the element intraclass correlation do not change. This is likely to be true for grids analysed by Slater's INGRID (1971), FOCUS (Shaw, 1980) and a new package being developed by the authors. Thus a microprocessor to hand during an elicitation, and into which the growing grid is fed, enables a practitioner to know what is happening with respect to the cognitive complexity of the respondent, and to assist him (or her) in managing the elicitation as well as giving advance warning of the time when further construct elicitation is unlikely to be of additional value.

The authors would like other researchers to evaluate the approach outlined in this paper, either with existing data, or during elicitation of new data, so that the value of this statistic may be further examined. A simple program has been written in BASIC (no matrix operators) for a 380-Z system, which, at present, accommodates 20×20 grids in 56K core. This programme is available as a listing from the authors.

References

ADAMS-WEBBER, J. (1969). Cognitive complexity and sociality. *Brit. J. of Social and Clinical Psychology*, **8**, 211–216.

ADAMS-WEBBER, J. (1970). An analysis of the discriminate validity of several repertory grid indices. *Brit. J. of Psychology*, **61**, 83–90.

BANNISTER, D. (1960). Conceptual Structure. Thought disordered schizophrenics. *J. Mental Science*, **106**, 1230–1249.

BANNISTER, D. (1962). Personal construct theory: a summary and experimental paradigm. *Acta Psychologica*, **20**, 104–120.

BIERI, J. (1955). Cognitive complexity-simplicity in predictive behaviour. *J. of Abnormal and Social Psychology*, **51**, 263–268.

BIERI, J. (966). *Clinical and Social Judgement: the Discrimination of Behavioural Information.* New York: Wiley.

BONARIUS, J. C. J. (1965). Research in the personal construct theory of George A. Kelly: role construct repertory test and basic theory. In MAHER, B. A., Ed., *Progress in Experimental Personality Research*, Vol. 2, pp. 2–46. New York & London: Academic Press.

FRANSELLA, F. & BANNISTER, D. (1977). *A Manual for Repertory Grid Technique.* London: Academic Press.

GOWER, J. C. (1977). The analysis of three way grids. Chapter 12 in SLATER, P., Ed., *The Measurement of Intrapersonal Space by Grid Technique*, Vol. 2. *Dimensions of Intrapersonal Space.* London: Wiley.

KEEN, T. R. (1979). Pedagogic styles in physics education: an attitude scaling and repertory grid study. Ph.D. thesis, Open University, Milton Keynes, U.K.

LANDFIELD, A. W. (1971). *Personal Construct System in Psychotherapy.* Chicago: Rand McNally.

MAIR, M. (1964). The deviation, reliability and validity of grid measures, some problems and suggestions. *Brit. Psych. Society Bulletin*, **17**, 55.

METCALFE, R. J. A. (1974). Own vs. provided constructs in a reptest measure of cognitive complexity. *Psychological Reports*, **35**, 1305–1306.

RATHOD, P. (1980). Methods for the analysis of rep. grid data. In BONARIUS, H., HOLLAND, R. & ROSENBERG, S., Eds., *Personal Construct Psychology: Recent Advances in its Theory and Practice.* London: Macmillan.

SHAW, M. (1980). *On Becoming a Personal Scientist.* London: Academic Press.

SHAW, M. & THOMAS, L. (1978). FOCUS on education—an interactive computer system for the development and analysis of repertory grids. *International J. of Man–Machine Studies*, **10**, 139–173.

SLATER, P. (1977). *The Measurement of Intrapersonal Space by Grid Technique*, Vol. 2. *Dimensions of Intrapersonal Space.* London: Wiley.

VANNOY, J. S. (1965). Generality of cognitive complexity–simplicity as a personality construct. *J. of Personality and Social Psychology*, **2**, 385–396.

WARREN, N. (1966). Social class and construct systems: examination of the cognitive structure of two social class groups. *Brit. J. of Social and Clinical Psychology*, **4**, 254–263.

Direct analysis of a repertory grid†

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A new exploratory method of analysing data in the form of a repertory grid is described. The method starts by carrying out single-link hierarchical cluster analyses of the elements and the constructs separately. These two marginal analyses are then used to rearrange the rows and columns of the original grid so that similar constructs and similar elements are grouped together. Data clusters are then identified that indicate those constructs or groups of constructs responsible for the groupings of the elements. The data clusters also take the form of a tree. The result of the analysis is a rearrangement of the original grid on which the row and column marginal trees and the data clusters may be superimposed.

The direct method presented here is based on a modification of Hartigan's (1975) joiner-scaler algorithm. It is useful for repertory grids since it emphasizes the interaction between constructs and elements, making it easier to identify unusual applications of constructs. This makes it particularly attractive in clinical settings. An added bonus is that the presentation of results is sufficiently simple to make it useful for the clinician who needs a way of identifying important structural aspects of the grid that does not depend on a detailed understanding of data analysis.

The method may be applied equally well to dichotomous, ranked or rating scale versions of a repertory grid. Missing entries, which may arise as a result of a construct not being applicable to some of the elements, may also be included.

1. Introduction

A repertory grid is a particular example of a cases by variables data matrix usually generated by a single individual. The cases are known as elements and the variables as constructs. The term repertory grid is generally reserved for matrices for which the constructs have been elicited from the individual. The standard method of eliciting constructs is the triadic procedure described in Bannister & Fransella (1971). Other conceptually simpler methods of eliciting constructs have recently been introduced (see, for example, Landfield, 1976; Easterby-Smith, 1980; Keen & Bell, 1980); for some applications, these may be particularly attractive. Occasionally the term repertory grid is generalized to include also matrices for which the constructs have been provided by the investigator. The procedure described below is equally applicable in both cases.

Table 1 shows an example of a repertory grid, which comes from a study of bereavement carried out by Elspeth Stirling (1980). The grid was completed by a man, Mr B, whose wife had recently died of cancer. It was obtained as part of a structured interview that focused on the man's life immediately before and after the bereavement. For the grid, he was asked to make judgements about eight elements, these being wife (W), self before bereavement (SB), self now (SN), general practitioner (GP), hospital doctor (HD), hospital nurse (HN), district nurse (DN) and close friend (CF). All seven

† A preliminary version of this paper was presented at the Mathematical and Statistical Psychology Section Conference, British Psychological Society, London, December 1978.

TABLE 1
Mr B's repertory grid as elicited

	1 Patient	2 Self Before	3 Self Now	4 GP	5 Hospital Doctor	6 Hospital Nurse	7 District Nurse	8 Close Friend	A	*vs.*	Blank
1	○	A	A	A	A	A	A	A	administering comfort	*vs.*	not
2	A	A	○	A	A	A	A	A	life dear to me — "happy"	*vs.*	not so much
3	A	A	A	A	○		A	A	serious approach/involvement	*vs.*	more flamboyant
4	○			A	A	A	A		concerned but not despondent	*vs.*	despondent
5		○		A	A	A	A		more able to keep comfortable — trained	*vs.*	helpless, not having medical knowledge
6	A	A	A	A			○	A	appreciation of life due to circumstances (learning)	*vs.*	not so much (learning)
7			○	A	A	A			continuing with life as before (ministry)	*vs.*	wiser, humble — reached this point

constructs were elicited from Mr B using the standard triadic method, the circles in each row showing the elements used to elicit the relevant construct. For each construct elicited, he was asked to decide which pole was most applicable to each of the elements. He was given the option of not having to apply all constructs to all elements if he wished, but he did not exercise this option, so the resulting dichotomous grid has all its entries intact. This grid was obtained in the pilot stage of Stirling's study and is much smaller than similar grids obtained in the main part of the study. However, we shall use this grid to illustrate the direct method of analysis, even though it is smaller than would be desirable in an actual application.

Repertory grids have been used for many different purposes; some idea of the wide range of uses may be obtained from the Bibliography of Fransella & Bannister (1977) or from Slater (1976) or from Adams-Webber (1979). The different uses may require different methods of analysis that emphasize features of the grid seen as being important for a particular study. The present paper concentrates on the exploratory use of repertory grids in a clinical setting as a way of supplementing more detailed clinical interviews. This use is exemplified in Stirling's study.

The aim of a method of analysis in such a setting should be to reveal important features of the grid that might not be obvious at first sight to a clinician who may not have much experience of data analysis. The features revealed will of course depend on the assumptions involved in the method of analysis, so it would help to have the assumptions made as obvious as possible.

Perhaps the most popular method of analysing grids is principle components analysis [see, for example, Slater (1977) or Kendall (1975) for a formal account, or Ryle (1975) for an informal account from the clinician's viewpoint]. Since the first two or three components typically account for a large proportion of the variance, it is possible to reveal much of the structure of the grid by plotting the elements and/or the constructs in 2- or 3-dimensional pictures [see, for example, Ryle (1975)]. This analysis has proved particularly informative for many users, but it has a number of disadvantages. The first is that the analysis does not reveal interactions between constructs and elements directly, even though the constructs and elements may be plotted together on the same display. Such interactions may take the form of several constructs being used in a similar manner when applied to one group of elements but differently when applied to another group of elements. Similarly a single construct may be used in the same way as others for most of the elements but there is a marked difference when applied to one particular element. These interactions may be particularly important in a clinical setting. They may be revealed by a careful look at the residuals in the analysis, but are not immediately accessible from the display. This is a particular disadvantage for the naive user of grids, who may concentrate attention on the visual display at the expense of the residuals.

A second disadvantage of a principal components analysis for a clinical user is that it is very tempting to look no further than the first two components, since they are easy to display, and neglect to notice how much of the variance in the data is accounted for by the remaining components. Users may ignore the fact that some grids may have very little of the variance accounted for by the first two components while other grids may have most of it accounted for. The 2-dimensional display will provide an adequate representation of the grids in the latter case but will be misleadingly oversimplified in the former case.

A third disadvantage is that the results of a principal components analysis are removed from the raw data, so that the user has to learn to make sense both of the original representation in terms of the grid and of the representation in terms of component loadings and residuals. In addition, the user may find it difficult to relate one representation to the other.

Other workers have used one of the many versions of hierarchical cluster analysis to reveal clusters of similar elements or similar constructs [see, for example, Riley & Palmer (1976)]. Such an analysis starts by computing distances between all possible pairs of elements (or constructs) and simplifying the resulting distance matrix to form a tree or dendrogram that reflects similarities and differences between the elements (or constructs). Like the 2-dimensional display of a principal components analysis, the resulting tree provides a simplified representation of the structure of the grid. The results of the two sorts of analysis are frequently similar, but it is worth noting that Holman (1972) has shown that data for which a hierarchical cluster analysis is perfectly applicable (in the sense that the tree completely captures the underlying structure) will be distorted if only the first two or three principal components are considered. The reverse is also true. This means that principal components analysis may be more appropriate than hierarchical cluster analysis for some grids, but for other grids cluster analysis will be more appropriate. However, Holman's result is based on a consideration of error-free data. In practice, when analysing real data, it would be expected that the two types of analysis will give broadly similar results, as argued by Kruskal (1977) when comparing multidimensional scaling and cluster analysis. In any event, for a given grid, the appropriateness of a hierarchical cluster analysis may be assessed using one of the available measures of goodness of fit, for example, Lerman's H introduced by Lerman (1970) and described by Leach & Green (1973), or Jardine & Sibson's (1971) delta measures discussed by Sibson (1973).

Cluster analysis shares the disadvantages of principal components analysis mentioned above. For example, the tree resulting from a hierarchical cluster analysis of the elements does not allow interactions between constructs and elements to be revealed; it may oversimplify the structure of the grid; and it is removed from the grid, so that the user has to work with two representations of the same data.

As a general purpose method of analysis that may be applied to many different grids, a principal components analysis is probably preferable to a cluster analysis, since the residuals provide helpful information for the user experienced in data analysis. However, despite this, the simplicity of many versions of hierarchical cluster analysis make them more attractive to the naive user.

Hierarchical cluster analysis has one further advantage over principal components analysis that will be exploited in this paper. It is possible to carry out a cluster analysis of the elements and a separate analysis of the constructs. The two resulting marginal trees may be used to rearrange the rows and columns of the original grid so that similar constructs and similar elements are grouped together. This makes the complete raw data available on the same display as the marginal cluster analyses. Several workers have found this particularly useful for feeding back information about grid structures to naive users [see, for example, Shaw & Thomas (1978)]. The algorithm described below goes one stage further than this and provides, in addition to the two marginal trees, a hierarchical analysis reflecting the interactions in the grid. It is based on the two-way clustering algorithms introduced by Hartigan (1972, 1975) and is a modification of Hartigan's joiner-scaler algorithm. The differences between the present method and Hartigan's method are discussed in section 4, below, but first the algorithm will be described in detail.

2. The direct algorithm

The algorithm produces three distinct trees representing, respectively, clusters of similar elements, clusters of similar constructs, and clusters of similar data items, these latter reflecting the interaction structure in the grid. The construction of the three trees will be described in turn below. The basic algorithm will be illustrated using the dichotomous grid in Table 1. The algorithm may be generalized quite straightforwardly to allow grids obtained by ranking or rating scale methods (see Fransella & Bannister, 1977) to be analysed similarly as shown in section 3, below. The suggested technique for handling missing entries is also described in section 3.

ELEMENT TREE

The analysis of the elements requires first the calculation of distances or dissimilarities between all possible pairs of elements. An appropriate measure of distance between a pair of elements in a dichotomous grid is the proportion of constructs on which the two elements fall on different poles. For example, in Table 1, elements 1 and 2 differ on only one of the seven constructs, so the distance between them is 1/7 or 0·14. The distances between all possible pairs of elements calculated in this way are shown in the element distance matrix in Table 2. The distances necessarily lie between 0 and 1.

This distance matrix is now analysed using a single-link hierarchical cluster analysis. This is the simplest form of hierarchical cluster analysis for which many computer programs are available (e.g. Gower & Ross, 1969; Sibson, 1973; Hartigan, 1975). It has a long history and has been suggested independently by several workers; in psychology, it frequently goes under the name of the connectedness or minimum method and is associated with the name of Johnson (1967), although it was originally suggested ten

TABLE 2
Element distance matrix

	1	2	3	4	5	6	7	8
1								
2	0·14							
3	0·29	0·14						
4	0·57	0·43	0·57					
5	0·86	0·70	0·86	0·29				
6	0·86	0·70	0·86	0·29	0			
7	0·57	0·43	0·57	0·29	0·29	0·29		
8	0·14	0	0·14	0·43	0·70	0·70	0·43	

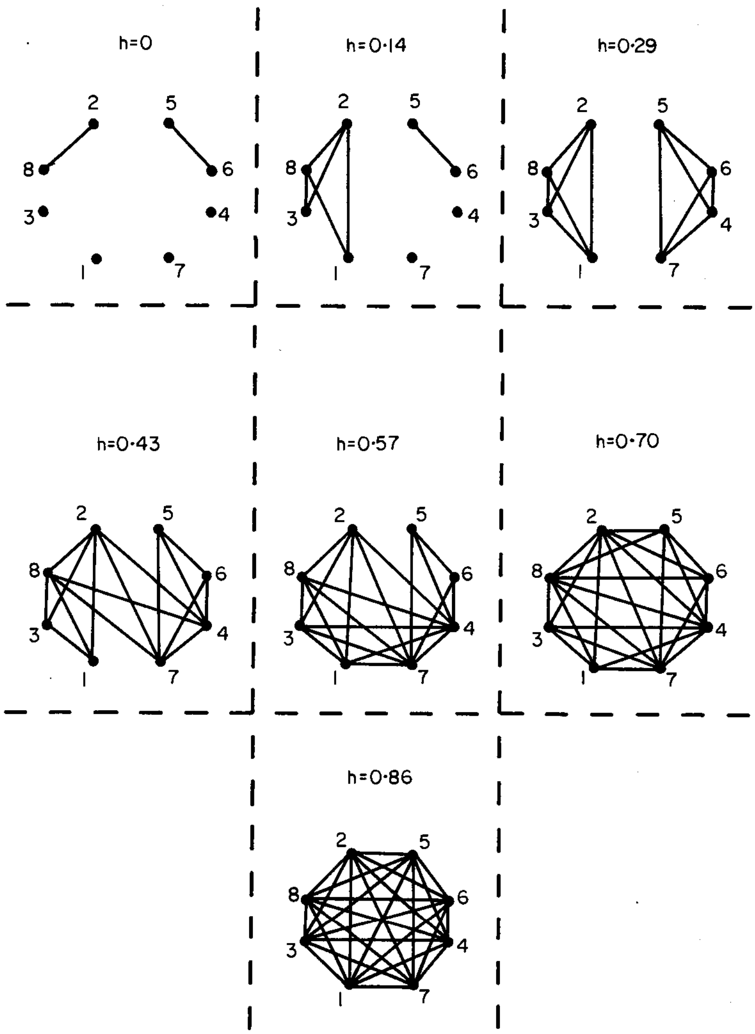

FIG. 1. Sequence of graphs illustrating the single-link algorithm.

years ealier in the numerical taxonomy literature by Sneath (1957). The single-link algorithm may be given a simple graph-theoretic description (Wirth, Estabrooke & Rogers, 1966; Jardine & Sibson, 1968), as follows. From the distance matrix, each numerical level, h, is taken in turn; a graph is drawn whose vertices represent the elements and whose edges join together those elements with a distance $\leqslant h$. For the data in Table 2, there are seven distinct distances; the corresponding sequence of seven graphs is shown in Fig. 1. At each level, the connected components of the associated graph define a partition of the elements; for example, the partition at level 0 is {(2, 8), 1, 3, (5, 6), 4, 7}, while the partition at level 0·14 is {(2, 8, 1, 3), (5, 6), 4, 7}. The sequence of partitions may be drawn in tree form as in Fig. 2 or in the more compact list notation as (((2, 8), 3, 1), ((5, 6), 4, 7)).

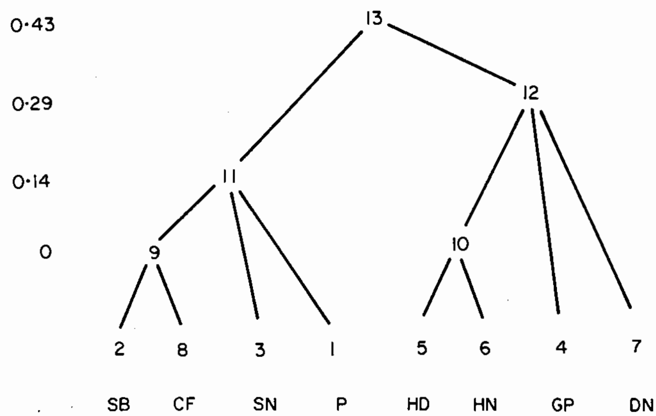

FIG. 2. Single-link cluster analysis of element distance matrix.

This summarizes the information in the distance matrix in a simple way. In the tree form the distance between any pair of elements is represented by the lowest level in the tree at which there is a common node or branching point. In Fig. 2, there are two main distinct clusters of elements. In some cases, the tree constructed in this way will adequately capture most of the information in the distance matrix, while in other cases it may be a gross oversimplification. For this example, the structure implicit in the distance matrix is well represented by the tree.

For convenience in referring to the clusters represented by the tree, each node of the tree is given a numerical label. If there are m elements, the node representing the most similar cluster of elements is labelled $m+1$, the next node is labelled $m+2$, and so on, as illustrated in Fig. 2.

CONSTRUCT TREE

The analysis of the constructs proceeds in a similar fashion to that of the elements. The first requirement is a measure of distance between pairs of constructs. For the subsequent analysis of the interactions the distance measure for the constructs needs to be broadly comparable with that for the elements. Unfortunately it is not possible to use the same distance measure in both cases, since counting the proportion of mismatches is inappropriate as a measure of distance for constructs, as pointed out, for example, by

Phillips (1973). For the constructs, some form of correlation coefficient or measure of association provides the appropriate starting point. In dichotomous grids, the most appropriate of these is the phi coefficient. The arguments favouring the phi coefficient in this situation are discussed in detail by Leach (1979), and will be outlined briefly in section 4, below.

The phi coefficient measures similarity between constructs on a scale from -1 to $+1$. To be able to compare the construct tree with the element tree we want a measure of dissimilarity or distance between constructs on a scale from 0 to 1. We can easily transform phi coefficients to distances by calculating $1-$ abs (ϕ), where abs (ϕ) is just the absolute value of the phi coefficient. It is reasonable to ignore the sign of phi here, since a negative value may be converted into a positive value merely by reversing the poles of one of the constructs involved.

The distance matrix for constructs is shown in Table 3. To illustrate the procedure, the entry in the (3, 1) cell is obtained as follows. The value of ϕ obtained by comparing constructs 1 and 3 is $-0{\cdot}22$, so the distance between 1 and 3 will be $1-0{\cdot}22$ or $0{\cdot}78$.

TABLE 3
Construct distance matrix

	1	2	3	4	5	6	7
1							
2	0·86						
3	0·78	0·78					
4	0·62	0·62	0·42				
5	0·62	0·62	0·42	0			
6	0·71	0·71	0·25	0·23	0·23		
7	0·71	0·71	0·25	0·23	0·23	0·54	

This distance matrix is now analysed using a single-link hierarchical cluster analysis in exactly the same way as with the elements to produce a tree reflecting similarities between constructs. The resulting construct tree is shown in Fig. 3. There appears to be one main cluster of constructs, (4, 5, 6, 7, 3), with constructs 1 and 2 being different from the rest.

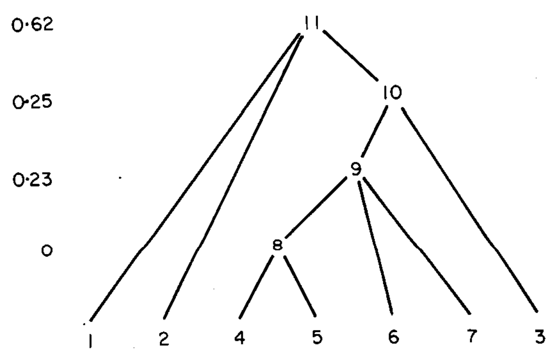

FIG. 3. Single-link cluster analysis of construct distance matrix.

REARRANGING THE GRID

The two marginal trees give us quite a useful summary of the main features of the grid structure. We now look at the interactions in the body of the grid, which may confirm or cause us to modify the interpretation based on the marginal trees. The first stage in the interaction analysis is to reorder the rows and columns of the grid to conform to the two marginal analyses. This is done in Table 4. To simply the description of the interaction

TABLE 4
Rearranged grid

	2	8	3	1	5	6	4	7
1	A	A	A		A	A	A	A
2	A	A		A	A	A	A	A
4					A	A	A	A
5					A	A	A	A
6	A	A	A	A			A	
7					A	A	A	
3	A	A	A	A			A	A

analysis below and to make the structure of the grid more evident we need to ensure that correlations between constructs in each cluster are positive. This involves reversing the poles of some of the constructs to change the sign of the correlations with other constructs.

This may be achieved by representing the construct distance matrix as a complete weighted graph, with vertices representing the constructs and edges weighted by the distances between pairs of constructs. From this the minimum spanning tree may be obtained quite straightforwardly (see, for example, Gower & Ross, 1969; Even, 1973). Gower & Ross (1969) have shown that the single-link cluster analysis bears a direct relation to the minimum spanning tree, and the single-link tree may be obtained from the minimum spanning tree very simply. The minimum spanning tree obtained from the construct distance matrix in Table 3 is shown in Fig. 4. When there are ties in the

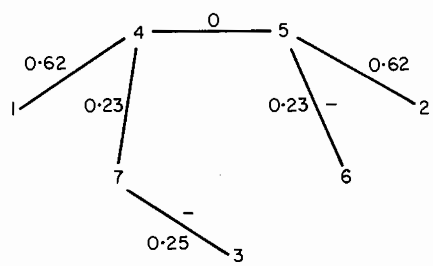

FIG. 4. Minimum spanning tree for the construct distance matrix.

distance matrix, as in this case, the minimum spanning tree may not be unique. We now replace the weights (distances) on the edges in the minimum spanning tree by the sign of the phi coefficient from which the distances were calculated. Negative signs are then removed by reversing the poles of some of the constructs. In our example, only the correlations between constructs 3 and 7 and constructs 6 and 5 are negative. These may by removed so that the minimum spanning tree has only positive weights on its edges by reversing the poles of constructs 3 and 6. It may easily be proved by induction that all the negative weights may be removed from any minimum spanning tree by reversing the poles of a subset of the constructs. Doing this in the grid in Table 4 gives the final rearranged grid shown in Table 5.

TABLE 5
Rearranged grid with constructs 6 and 3 reversed

G_0	2	8	3	1	5	6	4	7	
1	A	A	A		A	A	A	A	
2	A	A		A	A	A	A	A	
4					A	A	A	A	
5					A	A	A	A	
6					A	A		A	Reversed
7					A	A	A		
3					A	A			Reversed

DATA TREE

The raw grid, rearranged as in Table 5, provides the data matrix $\{G_0(I, J),\ 1 \leq I \leq N,\ 1 \leq J \leq M\}$, from which the data tree is constructed. In our case, $M = 8$, the number of elements, and $N = 7$, the number of constructs. The construct labels appear in the vector $\{IR_0(I),\ 1 \leq I \leq N\}$, which specifies the rearrangement of the rows that produces Table 5 from Table 1. Similarly, the element labels appear in the vector $\{JC_0(J),\ 1 \leq J \leq M\}$, which specifies the rearrangement of the columns. In addition, we require a weight matrix $\{W_0(I, J),\ 1 \leq I \leq N,\ 1 \leq J \leq M\}$ consisting entirely of 1's, representing the initial equal weight assigned to each cell of G_0 in the analysis.

G_0 has as its rows and columns the original constructs and elements. It is replaced successively by matrices $G_1, G_2, \ldots, G_n$, the rows and columns of which are clusters of constructs and clusters of elements as defined by the two marginal trees. The final matrix, G_n, consists of either one row or one column, At each stage in this replacement procedure, data clusters may be created that represent exceptions to the rules implied by the marginal trees. The row and column pointers to the cells in G_k for which these data clusters have been created are contained in the vectors DR and DC. At the same time, W_0, IR_0, and JC_0 are replaced successively by $W_1, W_2, \ldots, W_n$, $IR_1, IR_2, \ldots, IR_n$, and $JC_1, JC_2, \ldots, JC_n$.

G_{k+1} is obtained from G_k by finding the smallest distance at which a cluster of the items in G_k is formed in either marginal tree. If tied distances occur within a single tree, any of them may be selected. However, if both the construct tree and the element tree contain the same smallest distance, these must be considered together. We consider this most general case first, The cases for which no ties occur are then special cases of this algorithm. Suppose the smallest distance not already considered occurs in both the construct tree and the element tree; in the construct tree at this distance rows $i, i+1, \ldots, i+p$ are clustered in G_k; in the element tree columns $j, j+1, \ldots, j+q$ are clustered in G_k. The items in the clusters will necessarily be consecutive rows or columns of G_k because the initial grid G_0 has been rearranged to conform to the two marginal trees.

The $p+1$ rows clustered at this level are replaced in G_{k+1} by a single row whose rth entry is determined as follows. If $r<j$ or $r>j+q$, the rth entry is given by the "modal" value of the set $\{G_k(i, r), G_k(i+1, r), \ldots, G_k(i+p, r)\}$. This modal value is determined by finding that value for which the sum of the corresponding entries in W_k is largest. If all $p+1$ values are identical, no data clusters are formed. For any b such that $1 \leq b \leq p$, if $G_k(i+b, r)$ is defined but not equal to the modal value, a data cluster is formed by defining $\mathrm{DR(next)} = \mathrm{IR}_k(i+b)$, $\mathrm{DC(next)} = \mathrm{JC}_k(r)$. Similarly, if there is no unique modal value, $p+1$ data clusters are formed by defining $\mathrm{DR(next)} = \mathrm{IR}_k(i)$, $\mathrm{DR(next}+1) = \mathrm{IR}_k(i+1), \ldots, \mathrm{DR(next}+p) = \mathrm{IR}_k(i+p)$, $\mathrm{DC(next)} = \mathrm{JC}_k(r), \ldots, \mathrm{DC(next}+p) = \mathrm{JC}_k(r)$. In this latter case $G_{k+1}(i, r)$ is set equal to $-\infty$, where $-\infty$ is any number that does not appear in G_0. Finally, if $G_k(i+b, r) = -\infty$, no data cluster is formed.

When $j \leq r \leq j+q$, the rth entry in row i of G_{k+1} is given by the modal value of the submatrix defined by $\{G_k(s, t), i \leq s \leq i+p, j \leq t \leq j+q\}$. Data clusters, where necessary, are formed in a manner analogous to that defined in the previous paragraph.

The $q+1$ columns clustered at the level we are considering are replaced in G_{k+1} by a single column whose entries are defined as for the rows.

TABLE 6

Constructing the data tree

G_1

	9	3	1	10	4	7
1	A	A		A	A	A
2	A		A	A	A	A
8				A	A	A
6				A		A
7				A	A	
3				A		

W_1

9	3	1	10	4	7
2	1	1	2	1	1
2	1	1	2	1	1
4	2	2	4	2	2
2	1	1	2	1	1
2	1	1	2	1	1
2	1	1	2	1	1

G_2

	11	10	4	7
1	A	A	A	A
2	A	A	A	A
8		A	A	A
6		A		A
7		A	A	
3		A		

W_2

11	10	4	7
3	2	1	1
3	2	1	1
8	4	2	2
4	2	1	1
4	2	1	1
4	2	1	1

G_3

	11	10	4	7
1	A	A	A	A
2	A	A	A	A
9		A	A	A
3		A		

W_3

11	10	4	7
3	2	1	1
3	2	1	1
16	8	3	3
4	2	1	1

TABLE 6 (cont.)

G_4

	11	10	4	7
1	A	A	A	A
2	A	A	A	A
10		A	A	A

W_4

11	10	4	7
3	2	1	1
3	2	1	1
20	10	3	3

G_5

	11	12
1	A	A
2	A	A
10		A

W_5

11	12
3	4
3	4
20	16

G_6

	13
1	A
2	A
10	

W_6

13
7
7
20

	1	2	3	4	5	6	7	8	9	10
DR	1	2	6	7	3	3	10	1	2	10
DC	1	3	4	7	4	7	12	13	13	13

Corresponding to this replacement of the $p+1$ rows in G_k by a single row in G_{k+1}, the relevant $p+1$ entries in IR_k are replaced by a single entry in IR_{k+1} whose value is the numerical label attached to the cluster formed at this stage. Similarly, the relevant $q+1$ entries in JC_k are replaced by a single entry in JC_{k+1}.

The weight matrix W_k is also replaced by W_{k+1}. If $r<j$ or $r>j+q$, $W_{k+1}(i, r)$ is given by summing the values of $W_k(i, r)$, $W_k(i+1, r), \ldots, W_k(i+p, r)$ for which the corresponding entries in G_k contain the modal value used in G_{k+1}. When $j \leqslant r \leqslant j+q$, $W_{k+1}(i, r)$ is given by summing the values in the submatrix defined by $\{W_k(s, t), i \leq s \leq i+p, j \leq t \leq j+q\}$ for which the corresponding entries in G_k contain the modal value used in G_{k+1}. In either case, where no unique mode exists $W_{k+1}(i, r)$ is set equal to zero.

This replacement algorithm terminates when either of the marginal trees is exhausted. If the construct tree is exhausted first, G_n will contain a single row; if the element tree is exhausted first, G_n will contain a single column. The entries in G_n also form data clusters. The data clusters may now be superimposed on the rearranged grid along with the marginal trees. Once this has been done, the representation of the data clusters may be simplified to eliminate redundant clusters as shown in the final stages of Hartigan's (1975) joiner-scaler algorithm. The procedure is illustrated below.

For our example, G_0 is shown in Table 5, W_0 is a 7×8 matrix of 1's, while IR_0 and JC_0 are given by

$$IR_0 = \{1, 2, 4, 5, 6, 7, 3\},$$
$$JC_0 = \{2, 8, 3, 1, 5, 6, 4, 7\}.$$

The smallest distance in either marginal tree (Figs 2 and 3) is 0, which forms two clusters in the element tree and 1 in the construct tree. We can easily cope with all three clusters in one stage. No data clusters are formed, since, with distances of zero, there are no exceptions to the clusters defined by the marginal trees. G_1 and W_1 are then as shown in Table 6, with IR_1 and JC_1 given by

$$IR_1 = \{1, 2, 8, 6, 7, 3\}$$
$$JC_1 = \{9, 3, 1, 10, 4, 7\},$$

since constructs 4 and 5 are clustered at this level to form construct cluster 8, elements 2 and 8 form element cluster 9, and elements 5 and 6 form element cluster 10.

The next lowest distance in the marginal trees is the 0·14 in the element tree, forming cluster 11 from element clusters 9, 3 and 1. The entry $G_2(1, 1)$ is formed by considering the set $\{G_1(1, 1), G_1(1, 2), G_1(1, 3)\}$. These three entries are not identical, since $G_1(1, 1) = G_1(1, 2) = A$, but $G_1(1, 3) =$ blank. The sums of the corresponding entries in W_1 are $2 + 1 = 3$ (for the A's) and 1 (for the blank), so the modal value is A. We set $G_2(1, 1) = A$, and create a data cluster corresponding to the exception in cell $G_1(1, 3)$. $DR(1)$ is therefore set equal to $IR_1(1) = 1$ and $DC(1)$ is set equal to $JC_1(3) = 1$. $W_2(1, 1)$ is set equal to 3.

Similarly, $G_2(2, 1) = A$ and a second data cluster is formed from the exception to this rule found in $G_1(2, 2)$, so that $DR(2) = 2$ and $DC(2) = 3$. $W_2(2, 1)$ is set equal to 3.

The next lowest distance is the 0·23 in the construct marginal tree, which joins construct clusters 8, 6 and 7 to form cluster 9. This takes us from G_2 to G_3, and two more data clusters are formed on the way.

We proceed in this manner to G_6, which has a single column, since the construct tree contains the largest distance. The full analysis is shown in Table 6. The resulting data clusters are as follows:

DR	1	2	6	7	3	3	10	1	2	10
DC	1	3	4	7	4	7	12	13	13	13

We superimpose these over the rearranged grid by drawing a rectangle around the clusters of constructs and elements indexed by the respective entries in DR and DC. For example, the first data cluster instructs us to draw a rectangle around the entry corresponding to construct 1 and element 1, while the last data cluster instructs us to draw a rectangle enclosing all the entries corresponding to the construct cluster 10 and the element cluster 13. All ten data clusters have been drawn in this manner in Fig. 5, which also has the two marginal trees superimposed on the grid. From this it can be seen that entries within a data cluster are all identical, as will always be the case with this analysis. No simplification is possible, so Fig. 5 represents the final version of the grid.

From Fig. 5 it is clear that constructs 1 and 2 are used only to differentiate individual elements, while the two major clusters of elements are differentiated by the construct

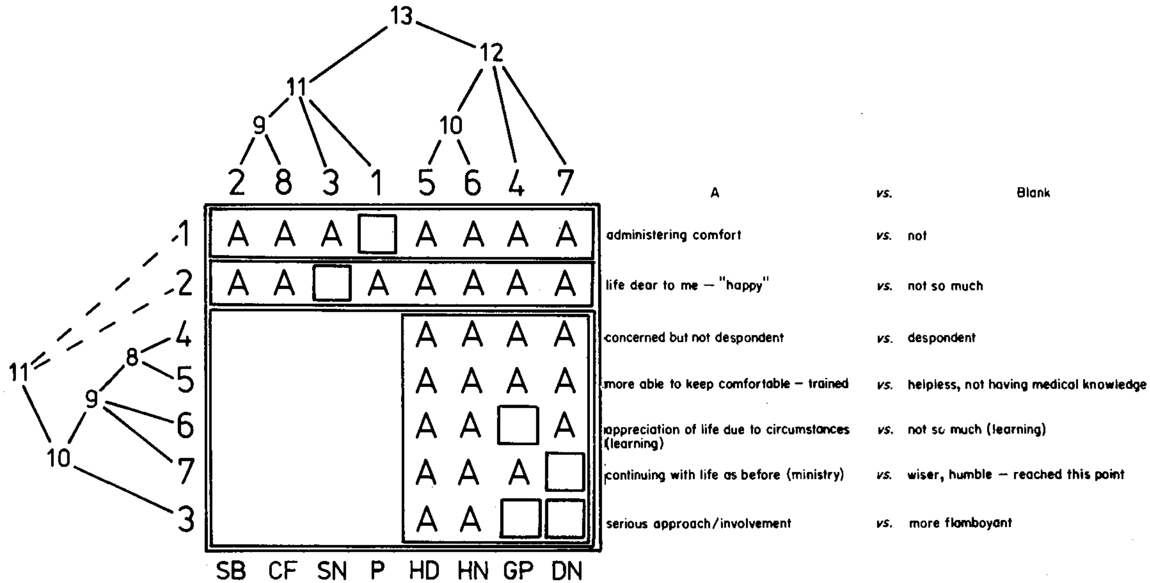

FIG. 5. The complete analysis of Mr B's grid.

cluster 10. Within this construct cluster, elements 2, 8, 3 and 1 are seen identically, with elements 5, 6, 4, and 7 being classified on opposite poles, although there are exceptions in the latter group.

3. Generalizing the direct algorithm

The direct method described here may be straightforwardly generalized to cope with ranked or rating scale grids and also to cope with missing entries in the raw grid. Both generalizations may be achieved by redefining the distance measure for elements and constructs.

For measuring the distances between elements in a ranked or rating scale grid, the standard technique is to calculate Euclidean distances as shown by Hartigan (1975). These may then be converted to the (0, 1) scale required by dividing the resulting distance by its maximum possible value for the particular rankings or rating scale used. The distances are calculated ignoring any comparisons involving missing entries. This measure of distance is appropriate also for dichotomous grids, since it reduces the proportion of mismatches in this case. Some people may prefer to use weighted Euclidean distances as defined by Hartigan (1975).

For measuring correlations between constructs in a ranked or rating scale grid, Pearson's product–moment correlation coefficient r is appropriate, where r is calculated ignoring any missing entries. For a dichotomous grid, r is identical to phi, so the appropriate measure of distance between constructs is $1-\text{abs}\ (r)$.

With the distance matrices calculated in this way, the marginal trees may be obtained as described in section 2. The only change necessary in the construction of the data tree is that those entries in W_0 corresponding to missing values in the rearranged grid G_0 are set equal to zero and the missing values each become separate data clusters.

The ability to handle missing entries is useful, since they may reflect elements outside the range of convenience of particular constructs, and these may provide important clinical information [see, for example, Landfield (1976)].

4. Differences from Hartigan's method

Although based on Hartigan's joiner-scaler algorithm, the present method differs from Hartigan's in three important respects that make it appropriate for repertory grid data.

1. Hartigan's method of constructing a scale for the variables involves using a measure of association between the variables (constructs) that is similar to Goodman & Kruskal's gamma. I have argued elsewhere (Leach, 1979) that phi is more appropriate than gamma as a measure of association for repertory grid data, since gamma will see constructs 1 and 2 in our example grid as perfectly associated while phi sees them as being more or less independent.

2. Hartigan's algorithm automatically weights the rows and columns of the grid differentially, so that very similar rows or very similar columns do not contribute too heavily to the analysis. This is achieved by calculating the marginal distances and the marginal trees as the data tree is constructed, and not using a weight matrix as above. I have chosen to assume that in a repertory grid it is preferable to weight all elements and all constructs obtained (including identical constructs) the same. With this assumption, the two marginal analyses may be carried out first, independently of the construction of

the data tree. Apart from speeding up the calculations, this seems more appropriate for most uses of repertory grids. If we only have access to the repertory grid, we have no way of knowing which constructs are the most important, superordinate ones and which are subordinate. It seems more reasonable to weight each construct identically rather than to reduce the weights of those constructs that are similar to each other. Similar constructs may well be reflecting a more superordinate idea that should be given more weight than isolated constructs.

3. Partly as a result of the unequal weighting, the outcome of Hartigan's algorithm may depend on the initial ordering of the rows and columns of the grid. This is not such a drawback in the present method.

5. Final comments

The marginal trees produced in the single-link analysis do not provide a unique ordering of the elements or constructs. For example, the element tree in Fig. 2, given in list notation as (((2, 8), 3, 1), ((5, 6), 4, 7)) could equivalently be written as (((1, 3, (2, 8)), ((5, 6), 4, 7)). The trees produced are rather like mobiles which pivot at the nodes forming the clusters, so that the items below any node may be twisted in any way that does not change the membership of the cluster. Gruvaeus & Wainer (1972) suggested a simple modification of the single-link algorithm that does result in a unique ordering of the items (as long as the relevant distance matrix does not contain ties). It may be informative to include this modification in the marginal trees of the present analysis; although it will not change the information in the analysis, it may help make the rearranged grid more tidy.

The most serious omission in this paper, common to most analyses of repertory grids, is a discussion of any error theory and the effect of errors on the outcome of the analysis. Apart from its simplicity, the single-link method was chosen here because Jardine & Sibson (1971) have shown it to be the least sensitive of the hierarchical clustering methods they consider to small changes in the data. However, no suggestions may be offered about the more general problem of error theory at this stage.

6. References

ADAMS-WEBBER, J. (1979). *Personal Construct Theory: Concepts and Applications.* Chichester: Wiley.

BANNISTER, D. & FRANSELLA, F. (1971). *Inquiring Man.* London: Penguin Books.

EASTERBY-SMITH, M. (1980). The design, analysis and interpretation of repertory grids. *International Journal of Man–Machine Studies*, **13**, 3–24.

EVEN, S. (1973). *Algorithmic Combinatorics.* New York: Macmillan,

FRANSELLA, F. &. BANNISTER, D. (1977). *A Manual for Repertory Grid Technique.* London: Academic Press.

GOODMAN, L. A. & KRUSKAL, W. H. (1954). Measures of association for cross classifications. *Journal of the American Statistical Association*, **49**, 732–764.

GOWER, J. C. & ROSS, G. J. S. (1969). Minimum spanning trees and single linkage cluster analysis. *Applied Statistics*, **18**, 54–64.

GRUVAEUS, G. & WAINER, H. (1972). Two additions to hierarchical cluster analysis. *British Journal of Mathematical and Statistical Psychology*, **25**, 200–206.

HARTIGAN, J. A. (1972). Direct clustering of a data matrix. *Journal of the American Statistical Association*, **67**, 123–129.

HARTIGAN, J. A. (1975). *Clustering Algorithms.* New York: Wiley.

HOLMAN, E. W. (1972). The relation between hierarchical and Euclidean models for psychological distances. *Psychometrika*, **37**, 417–423.

JARDINE, N. & SIBSON, R. (1968). The construction of hierarchic and non-hierarchic classifications. *Computer Journal*, **11**, 177–184.

JARDINE, N. & SIBSON, R. (1971). *Mathematical Taxonomy*. New York: Wiley.

JOHNSON, S. C. (1967). Hierarchical clustering schemes. *Psychometrika*, **32**, 241–254.

KEEN, T. R. & BELL, R. C. (1980). One thing leads to another: A new approach to elicitation in the repertory grid technique. *International Journal of Man–Machine Studies*, **13**, 25–38.

KENDALL, M. G. (1975). *Multivariate Analysis*. London: Griffin.

KRUSKAL, J. B. (1977). The relation between multidimensional scaling and clustering. In VAN RYZIN, J., Ed., *Classification and Clustering*. New York: Academic Press.

LANDFIELD, A. (1976). A personal construct approach to suicidal behaviour. In SLATER, P. Ed., *Explorations of Intrapersonal Space*. London: Wiley.

LEACH, C. (1979). *Introduction to Statistics: A Nonparametric Approach for the Social Sciences*. Chichester: Wiley.

LEACH, C. & GREEN, T. R. G. (1973). Uses and abuses of hierarchical cluster analysis. Paper presented at the Mathematical and Statistical Psychology Section Conference, British Psychological Society, Birmingham, June 1973.

LERMAN, I. C. (1970). *Les Bases de la Classification Automatique*. Paris: Gauthiers–Villars.

PHILLIPS, J. P. N. (1973). The use and analysis of repertory grids. Discussion paper presented at the Workshop on Reprtory Grids, organized by the Mathematical and Statistical Psychology Section, British Psychological Society, Bedford College, London, November 1973.

RILEY, S. & PALMER, J. (1976). Of attitudes and latitudes: A repertory grid study of perceptions of seaside resorts. In SLATER, P., Ed., *Explorations of Intrapersonal Space*. London: Wiley.

RYLE, A. (1975). *Frames and Cages: The Repertory Grid Approach to Human Understanding*. Sussex University Press.

SHAW, M. L. G. & THOMAS, L. F. (1978). FOCUS on education—an interactive computer system for the development and analysis of repertory grids. *International Journal of Man–Machine Studies*, **10**, 139–173.

SIBSON, R. (1973). SLINK: An optimally efficient algorithm for the single-link cluster method. *Computer Journal*, **16**, 30–34.

SLATER, P., Ed. (1976). *Explorations of Intrapersonal Space*. London: Wiley.

SLATER, P., Ed. (1977). *Dimensions of Intrapersonal Space*. London: Wiley.

SNEATH, P. H. A. (1957). The application of computers to taxonomy. *Journal of General Microbiology*, **17**, 201–226.

STIRLING, E. A. (1980). Care and support in terminal illness and bereavement: The relatives' perspective. Unpublished report, Newcastle upon Tyne Polytechnic.

WIRTH, M., ESTABROOKE, G. F. & ROGERS, D. J. (1966). A graph theory model for systematic biology with an example for the Oncidiinae (Orchidaceae). *Systematic Zoology*, **15**, 59–69.

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Printed in England

0.12.639260.9