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THE PERSONAL SCIENTIST IN THE COMMUNITY OF SCIENCE

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ABSTRACT

One of the key problems of a conventionalist epistemology such as that proposed by Kelly and developed in a number of our previous papers is to explain the way in which people do come to have common constructs and are able to communicate with one another. If we take Kelly's viewpoint to be epitomized by the concept of man as a personal scientist, then we also have to explain how a community of science can arise in which individuals can reach agreement on a common view of the world or on co-operative programs of action. In this paper we outline a model of the formation of communities of science which integrates Kelly's conventionalist epistemology with the normative epistemology of Popper's concept of world 3s. We also relate this to Wolff's model of "surrender and catch", to Pask's model of "P-Individuals", and to Grey's model of "system forming precursors".

INTRODUCTION

In a number of previous papers we have analysed the process whereby an individual models the world and have used George Kelly's (1955) concept of the personal construct systems underlying man's epistemological activities to present the individual as a personal scientist. We have operationalized part of Kelly's theory through computer programs that elicit personal constructs interactively (Shaw 1980a) and analysed the construct structures in a variety of ways (Gaines & Shaw 1980a). In particular we have proposed logical models of construct systems (Shaw & Gaines 1979, 1980) that relate them to Zadeh's (1976) fuzzy semantics and to the structures of fuzzy (Zadeh 1978) and generalized (Gaines 1979a) database systems.

In epistemological terms Kelly's "constructs" form the "source system" at the base of Klir's (1976) epistemological hierarchy, essentially the "domain of discourse" (Gaines 1977 p.165) for the description of observations of the world. Kelly emphasizes the personal nature of the source system for individuals and hence, in Klir's terminology, of the "data system" presenting actual observations of the world, and the "generative" and "structure" systems above it in which these observations are modelled. This is in contrast to conventional epistemological systems that suppose that some impersonal universality at all these levels is a hallmark of knowledge and certainly of science.

Thus, a key problem for a conventionalist epistemology such as that proposed by Kelly and developed in our previous papers is to explain the way in which people do come to have common constructs and are able to communicate with one another. From a positivist point of view there should be only one epistemological hierarchy. When we accept the liberalization of this to a plurality of such hierarchies we allow for the real-world phenomena of different "points of view", different "sciences", and even different "modes of science". However, we then have the actual communality of much of our knowledge, language and modelling systems to explain. If we take Kelly's viewpoint to be epitomized by the concept of man as a personal scientist, then we also have to explain how a community of science can arise in which individuals can reach agreement on a common view of the world or on co-operative programs of action.

In this paper we outline a model of the formation of communities of science which integrates Kelly's conventionalist epistemology with the normative epistemology of Popper's (1968) concept of world 3s, and relates it to Wolff's (1976) concept of surrender and catch, Pask's (1975) concept of P-Individuals and Grey's (1979) concept of system-forming precursors.

SURRENDER AND CATCH

In a previous discussion of the significance of interactive construct analysis (Gaines & Shaw 1980a p.109) we noted the context-dependency of construct systems and related this to the work of Wolff (1976) on the fundamental nature of role playing in epistemology. 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 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.

Wolff's (1976) book about "experience and

enquiry today" has much in it that is relevant to the formation of communities of science and the ways in which individuals enter into them. In particular his basic model of "surrender" to a situation so that one may "catch" the essence of it - of becoming through surrender someone different in order to catch hold of something different - gives a valuable insight into the nature of the processes involved in adopting construct systems in order to achieve knowledge and action. Wolff's book is fragmentary, discursive, literary, even poetic in places, and this is in itself also significant - we shall not catch the essence of any theory of knowledge from within its own framework of abstraction.

Wolff's model of surrender is most relevant to the current context in terms of his discussion of the nature of the "mathematician":

> "From the standpoint of the world of everyday life, the mathematician, as we often put it, lives in the 'world of mathematics', dealing with 'nonreal' elements, notably numbers, whose relation to 'real' things, to 'reality', is not part of his concern. Analogously for the logician. What makes our subject-object approach to this attitude misleading is the fact that the subject, the student of mathematics or logic - his or her individuality, including motives and attitudes - is irrelevant for our understanding; the only thing that counts is the pursuit, with its results and questions." (Wolff 1976 pp.162-163)

He makes the key point that not only does the real world, the object, disappear to be replaced by the world of mathematics, but also that in entering into this world the person doing mathematics, the subject, also disappears to be replaced by a new entity, the mathematician.

Wolff was not alone in these insights and there are three further models which develop and complement his. His notion of "object" has much in common with that of Popper's (1968) "world 3" of "statements in themselves"; his notion of "subject" has much in common with that of Pask's (1975) notion of "P-Individuals" or independent psychological processes; and his notion of "surrender" has much in common with Grey's (1979) "emotional-cognitive structure theory" with its emphasis on the role of "system-forming precursors".

Popper introduces his "3 worlds" model in his autobiography (Schilpp 1974 p.143) by quoting Bolzano's notion of "truths in themselves" in contradistinction to "those thought processes by which a man may...grasp truths", proposing that:

> "thoughts in the sense of contents or statements in themselves and thoughts in the sense of thought processes belong to two entirely different 'worlds'."

and making the three-fold distinction:

> "If we call the world of 'things' - of physical objects - the first world and the world of subjective experience the second world we may call the world of statements in themselves the third world (...world 3)."

This notion of a "world 3" is a useful representation of Wolff's "object" that we "catch" particularly when we note its distinct ontological status:

> "I regard the third world as being essentially the product of the human mind. It is we who create third-world objects. That these objects have their own inherent or autonomous laws which create unintended and unforseeable consequences is only one instance (although a very interesting one) of a more general rule, the rule that all our actions have such consequences." (Popper in Schilpp 1974 p.148)

Pask (1975 p.302) introduces the notion of a "P-Individual", or "psychologically characterized individual", in contradistinction to that of an "M-Individual", or "mechanically characterized individual". He notes that an M-Individual is characterized as:

> "a human being (or his brain) as a biologically self-replicating system",

whereas:

> "a P-Individual...has many of the properties ascribed by anthropologists to a role, in society or industry, for example. A P-Individual is also a procedure and, as such, is run or executed in some M-Individual, qua processor. However, it is quite exceptional to discover the (usually assumed) one to one correspondence between M-Individuals and P-Individuals"

This notion of a "P-Individual" as a coherent psychological process capable of engaging in "conversations" is a useful representation of Wolff's "subject" that "catches" through "surrender", particularly when we note that several P-individuals may execute within a single processor. Thus 'the mathematician' may engage in conversation with 'the physicist' or 'the statesman' all of whom happen to use the same brain for their processing.

Gray (1979) introduces his notion of "system-forming precursors" as part of his "emotional-cognitive structure theory" for "understanding creative thought processes". He hypothesizes that:

> "emotions might serve both as the integrating devices for the formation of thoughts and as the coding devices for their storage in memory"

He advances a model of thought formation through a "general system precursor formation theory" in which:

> "system formation proceeds when two or more system precursors are brought together in a relational sense"

and notes the existence of:

> "system precursor activators which serve to initiate the emergence of an organizing focus, and system blockers which inhibit system formation or which have the capability of returning an ongoing system to the precursor state."

This notion of "system formation" with its necessary "precursors" and heavy emotional content is a useful representation of Wolff's "surrender" which is itself a highly emotionally charged word for what would be conventionally chracterized as the 'learning' process.

Shaw (1980a) notes that each P-individual may have its own system of "personal constructs" and Kelly (1955) re-defines "emotions" in terms of reactions to changes, or threatened changes, in "core constructs". We thus have a model of a P-individual within a particular person using a particular construct system by which to surrender himself to a particular world 3 in order to catch its essence. This model of coherent intellectual processes, each with its own individuality, each using its own construct system to enter into an abstract world that has its own reality, provides a very cogent picture of the rationale behind, and the conflicts involved in, the interaction between our personal semantic spaces and our communal ones. It goes beyond any simple concepts of "role playing" by providing the basis for formal models of the mechanisms whereby P-individuals can enter into an abstract world. The "constructive alternativism" of Kelly provides a model for the extreme relativism of our conception of a world. However, its conventionalism needs counterbalancing by Popper's emphasis on the ontological independence of that world in itself.

A WORLD 3 SYSTEMS MODEL

Figure 1 illustrates diagrammatically the integrative model we have proposed. Person-A, Person-B and Person-C are each interacting with the same World 3 System-1 through personal construct systems that correspond to P-Individuals within each person. We have shown the construct systems of B and C overlapping to indicate that they have shared constructs. It is reasonable to suppose that they could establish linguistic communication between the two of them in terms of these shared constructs. Person-A, however, is shown as sharing no constructs with B and C even though he is interacting with the same World 3. This may seem strange but it is possible for someone to interact with essentially the same structure on a very different basis from someone else. For example consider two mathematicians, one of whom solves a geometry problem by direct geometric techniques and the other by algebraic techniques based on a co-ordinate system. It is the same problem they are tackling, and it is this which defines the world 3, but their views of it and the techniques they use are so different that they have virtually no common vocabularly for describing their different solution methods, how they interact with the world 3. In more formal terms we would describe them as being analogous to one another through the minimal analogy of the truth category formed by the world 3; otherwise there is no analogy between their methods and construct systems (Gaines & Shaw 1980b). This very clearly illustrates the ontological independence of a world 3 structure.

Figure 1 also shows a second P-Individual in Person-C interacting with a second World 3 System-2. The diagram may be extended to show situations where different P-individuals interact,

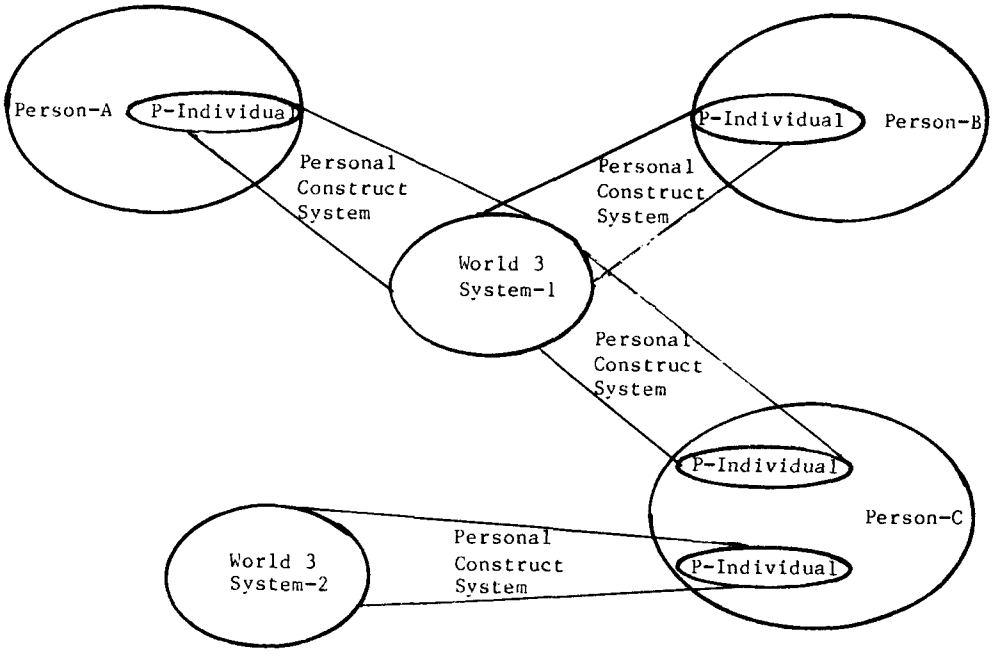


FIGURE 1 P-Individuals Surrendering to Catch Essence of World 3s through Personal Construct Systems

either through sharing partially common construct systems, or by interacting with the same world 3, or both. It may also be used to show situations where different world 3s themselves overlap. It is when the world 3s have some basis of autonomously interacting back with the people that we seem to distinguish them as real worlds. Note that the so-called physical world is not the only one with this kind of power; certain ideas and ideals seem to have a charisma of their own which gives them the strength of categorical imperatives, ideologies, religious truths, etc. This is reminiscent of Henry Adams' (1961) comparison of the hall of dynamos at the Great Exposition in Paris where they "became a symbol of infinity... a moral force, much as the early Christians felt the cross", with the Cathedral at Chartres: "All the steam in the world could not, like the Virgin, build Chartres." Gaines (1979b) has suggested that the computer is a source of energy for traversing Popper's world 3 much as was the steam engine for his world 1. Programs such as PEGASUS (Shaw 1980a) show how such a computational 'engine' can operate in practice.

LOGICS AND CONFLICT RESOLUTION

Perhaps an obvious question at this stage is as to the necessity of the 'schizophrenia' within the person operating a number of distinct P-Individuals. Even if we accept that this happens we do not have to accept that it is desirable. Quite the contrary - is not the ideal the "whole man" who integrates together all facets of his existence and is able to avoid conflicts between his being as a 'humanitarian' with his being as a 'scientist'? The basic problem here is one of over-determination. It is an easy one to neglect because we seem to pay far more attention to decisons under uncertainty where we have insufficient determination than to decisions under conflict where we have too much determination. We avoid such conflicts by using construct structures associated with particular world-views that filter out all other aspects of the world. To enter in the world of the mathematician is not only to learn to use new constructs that form the key to that world but also to learn to put aside others that would impede entry to that world. This is the way in which the world 3s themselves interact with the person to mould his construct system to make it possible for him to move about within them. In this process constructs may be changed or removed but this may endanger the capability of the person to operate in other worlds. Hence P-Individuals are formed within coherent clusters of constructs through which a person enters a particular world 3.

Clearly essential conflicts do not somehow magically disappear when a person establishes different P-Individuals. The overall result is that the conflicts may be avoided within a particular psychological processing unit and isolated to appear at the conversational boundaries between them. Each P-Individual can then have its own coherence not only in terms of self-consistency but also in terms of mutual consistency with others who subscribe to the same 'rules of the game'. For example to be a 'behavioural psychologist' is to view man in a certain way using a certain methodology and pattern of allowable inferences. Within the framework of psychological science there is an epistemic drive to explore fully all the behaviours of men. As 'psychologists' there are experiments which we would wish to perform which involve behaviour towards our fellow men which would clearly be unacceptable to us as 'humanitarians' (or 'law-abiding citizens' or ...). How we resolve the conflict between the differing objectives of the P-Individuals interested in such situations is clearly a significant problem. It has always been a major one for those involved in the science and technology of human life such as clinicians, and books such as The Social Responsibility of the Scientist (Brown 1971) point out that there are undesirable side effects from many scientific and technological activities otherwise regarded as of great value.

The ethical conflicts of medicine and other sciences are real and irresolvable. There are also lesser conflicts which are conveniently treated in the same way - it is conventional for us in scientific papers not to discuss the way in which our family holidays interacted with our experimental program (although it would often be helpful to know what parameters are those of experimental design and what of expediency!). If we do attempt to take the 'whole man' approach then our 'sciences' assume new dimensions - "E=MC." might become TRUE but UNREPORTED (due to dangerous consequences). Technically we can cope with the injection of ethical and other value schemata into science by using many-sorted modal logics to deal with the differing deontic modalities involved. So far we have not done this formally even for epistemic logics, e.g. to treat 'unknown' as a logical value of equal status to 'true' and 'false'. In practice, of course, much of the actual argument of scientific debate is based on informal epistemic logic, and in some disciplines such as elementary particle physics and cosmic physics epistemic constraints have come to dominate the interaction between theory and experiment - we are dealing with entities whose time and space scales are intrinsically too small, or too large, for definitive experiments to be feasible.

It is only in the last decade that formal methods for treating many-sorted epistemic and deontic logics have become available (Snyder 1967). The computational complexity of these treatments is such that the M-individual that is a human brain cannot be expected to support P-Individuals that can cope with them. It seems feasible that computers, or man-computer symbiotic systems, may be able to do so. Indeed this is a natural, and probably necessary, extension of current database systems (Gaines 1979a); and Belnap (1976) has already suggested that epistemic logics using "TOLD TRUE" and "TOLD FALSE" have a significant role in databases. He also notes that we might wish to go further and tag TOLD TRUE as TOLD TRUE BY X - clearly this may be extended to deontic predicates also, such as FELT WRONG BY Y, ILLEGAL IN FRANCE, and so on. Gaines & Shaw (1980a) show that Belnap's logic is the same as that being used by the logical construct analysis

program, ENTAIL, when it analyses data by Landfield (1976) that allowed the subject to assign elements not only to either pole of a construct but also to BOTH or NEITHER. Gaines (1979a) 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.

The development of automated database and inference systems with such capabilities does seem to be of potentially great importance and significance. However, it does not in any way avoid the basic problems already referenced. Any attempt to implement a consensual decision-maker within such a system is doomed to failure in general since it involves mapping many modalities down into a single set of necessity and impossibility. Such a mapping will give rise to contradictions just at those points where there are conflicts: A is NECESSARY because A is DESIRABLE and A is IMPOSSIBLE because A is ILLEGAL. The assertion of such a contradiction allows the derivation of any other statement - the decision-maker oscillates or hangs. If we derive consensual sub-systems from the database, for example over all mathematicians, then we obtain the "world 3" (of 'mathematics') within which move particular P-Individuals (who are 'mathematicians').

The technical development of formal logical systems representing the interactions of many P-Individuals with a range of world 3's seems feasible within the framework of possible worlds semantic models (Lewis 1973, Bradley & Swartz 1979). In general the process of construct formation is that of "making a distinction" (Brown 1969) and the logics based on this process necessarily involve the axiom of comprehension with its possible paradoxes (Hughes & Brecht 1976). It is significant that White (1979) has recently proved this axiom to be consistent in its unrestricted form in logics essentially based on Zadeh's (1965) fuzzy set theory. It is such logics that we have previously proposed as models for human reasoning (Gaines 1976) and used in our logical modelling of construct systems (Gaines & Shaw 1980a). Similar logics have been used by workers on "expert systems" (Michalski & Chilausky 1980) and shown by Goguen (1974) to be related to human concept formation.

COMPUTER ANALYSIS OF A COMMUNITY OF SCIENCE

The PEGASUS computer program for interactive grid elicitation (Shaw 1980a) acts as a dialectical partner to the person in aiding him to understand his personal semantic structure for a world. The techniques used in this operational form of Kelly's personal construct theory may be extended from the individual personal scientist to the group who through their construct structures form a community of science. 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. This is done by storing the "expert" grid in the computer, and as the user elicits a grid in the usual PEGASUS way, the feedback is given not only in terms of how the user's constructs map on to each other, but also how they map on to the bank of stored constructs (Shaw 1980b).

This technique can also be used to help 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 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. This may be seen as a logical extension of work on expert systems (Michie 1979) to the more general case of expertize distributed in a community. It may also be seen as a tool for aiding the "surrender" of an individual to a "world 3" defined by another who is an "expert" in the world 3 precisely because he is capable of that definition.

The SOCIOGRIDS computer program was devised in order to explore the similarities and differences in construing between members of a group. This technique is based on the assumption in Kelly's (1955) commonality corollary that there may be shared meaning among a 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 individuals in the group. The constructs elicited are personal to the individual, and the similarity between constructs is measured using an operational definition of how the construct orders the elements rather than on any literal or conceptual similarity. This may be seen as a process of extracting "P-Individuals" from a community of science, noting that there may be several P-Individuals within one brain and that several members of the group may be acting as one P-Individual.

Using the SOCIOGRIDS technique each individual in the group can have feedback on his own construing of the topic from a focused grid in which the rows and columns are re-ordered to highlight patterns of similarity (Shaw 1980a). In addition a "mode" grid of the most commonly used constructs from the group is extracted and focused. This then shows the content of the topic which the members of the group have in common. Each construct in the mode grid has been obtained from an individual in the group and is in no way changed when used in the mode. This grid 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 of construing within the group. These constructs are selected on the basis of how they order the elements not on linguistic labels, and hence tend to be tightly clustered into subsets of comparable meanings.

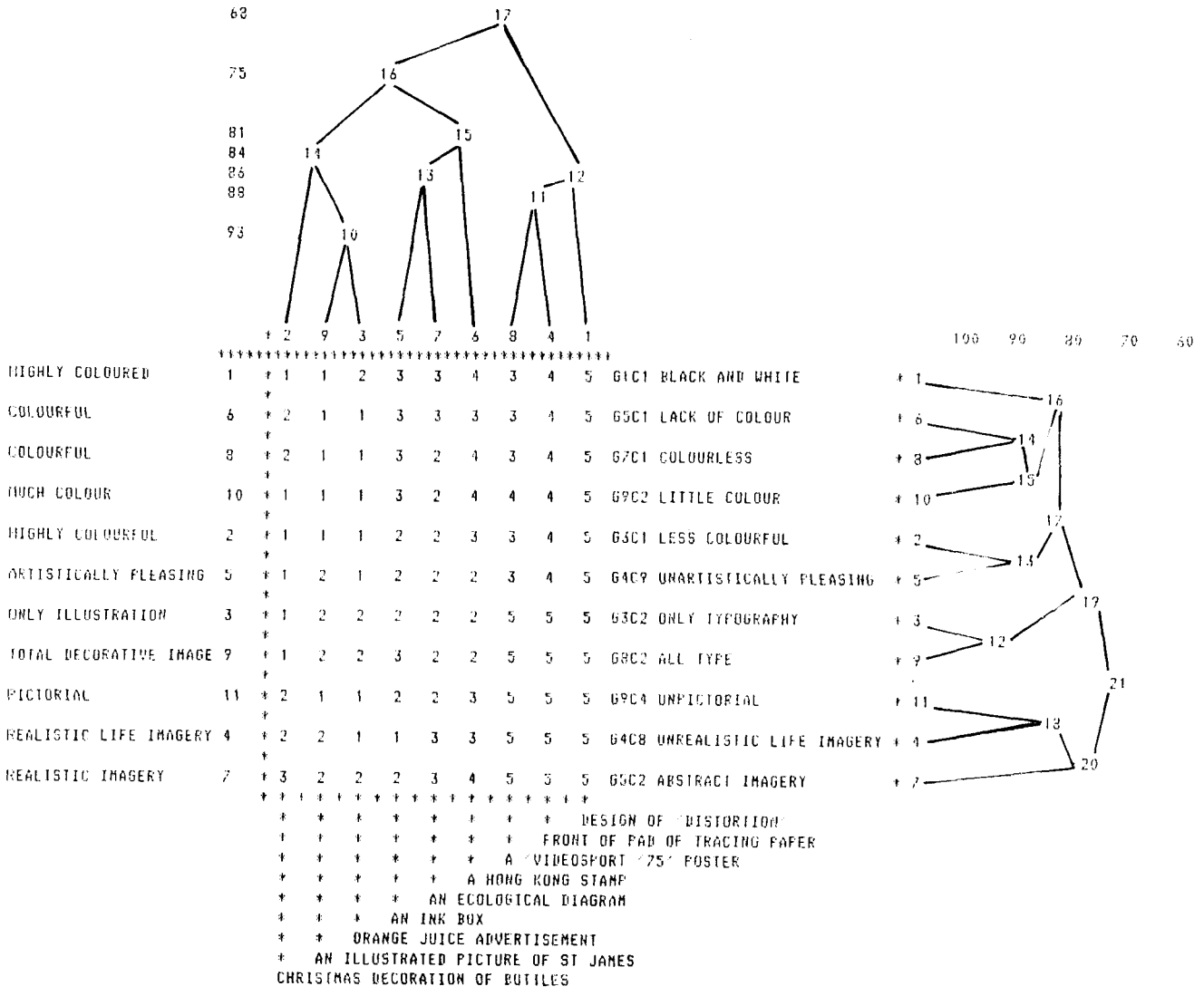


FIGURE 2 The Mode Grid on Graphic Art Objects

Figure 2 illustrates a mode grid from a group of art students who were concerned to examine the differences in the construing of the students and the tutor in the field of graphic art. The elements are pieces of graphic art contributed by individual members of the group and discussed in the group before being included. The first two main clusters which appear can be seen to express similar ideas in the different terminology of each individual.

The mode grid can then be used as a common referent with which to compare each member of the group. Figure 3 shows the combined grids of the mode and the grid of member 7 focused together, indicating the extent of the interaction between the two perspectives. In fact, this combination shows the most interaction, the least being shown by the combined grids of the mode with the grid of member 6. The significance of this appears when we examine the "socionets" which the program produces from the measures of similarity between pairs of individual grids. The socionets show the rank ordering of the most highly related pairs of individuals in the group and hence expose those members of the group who have the most in common and those with strongly individualistic viewpoints. Figure 4 shows the set of socionets from the group of art students. Firstly two highly related pairs emerge, 7 with 9 and 3 with 4. Gradually 2 is revealed as the person who has most in common with all the others, and the tutor joined the group at link 9. Not until all the other links have been made at stage 28 does person 6 join the group. He clearly shows a strongly individualistic point of view, and in fact chose to leave the group shortly after this time, not having seen these results.

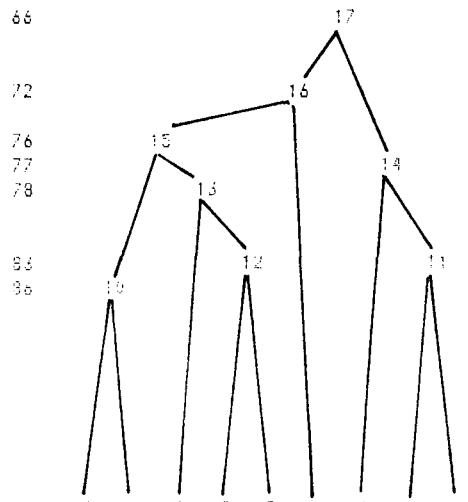
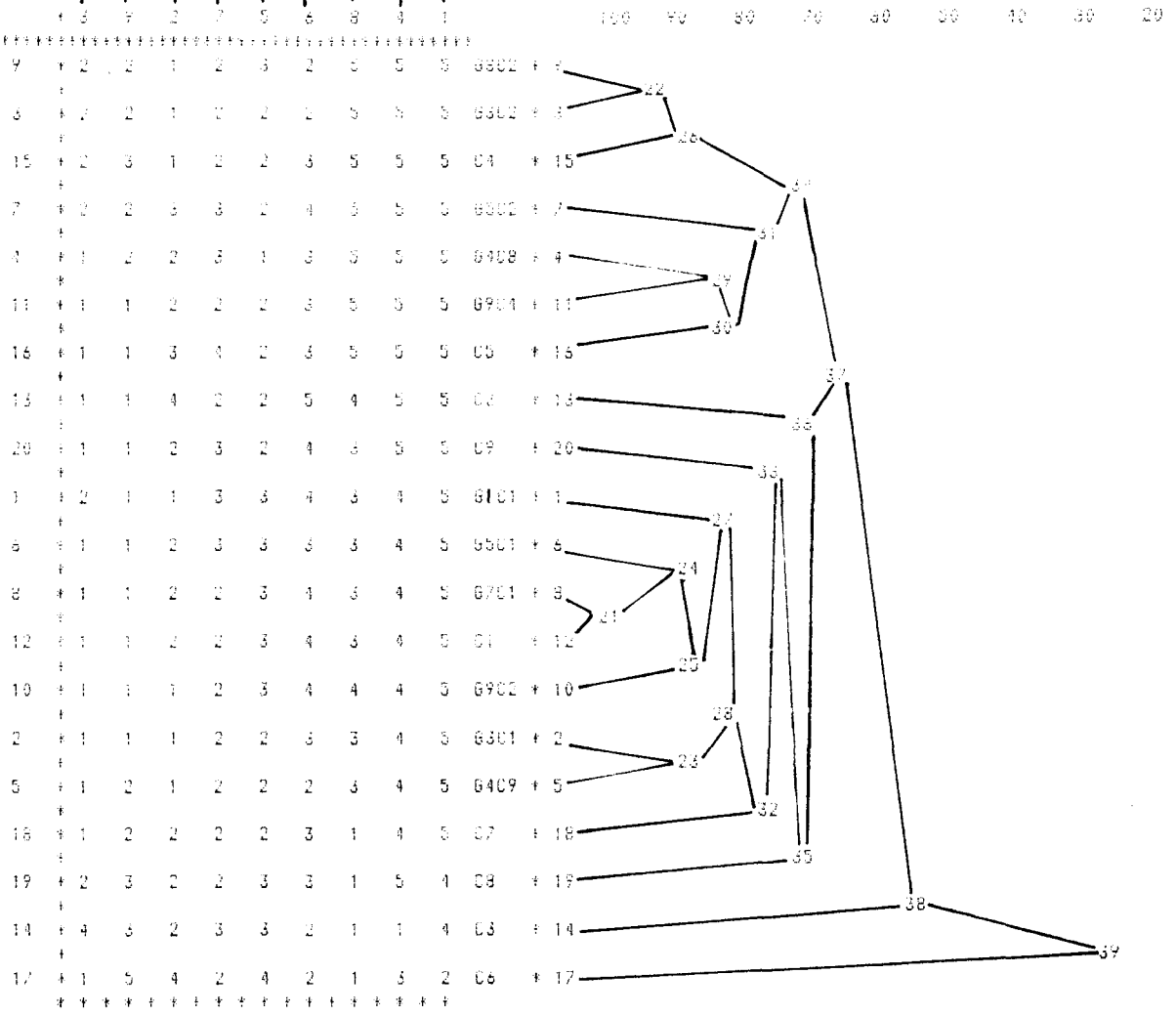


FIGURE 3 The Combined Grids of the Mode and the Grid of Member 7



DESIGN OF 'DISTORTION'
FRONT OF PAD OF TRACING PAPER
A 'VIDEOSPORT '75' POSTER
A HONG KONG STAMP
AN INK BOX
AN ECOLOGICAL DIAGRAM
CHRISTMAS DECORATION OF BOTTLES
AN ILLUSTRATED PICTURE OF ST JAMES
ORANGE JUICE ADVERTISEMENT

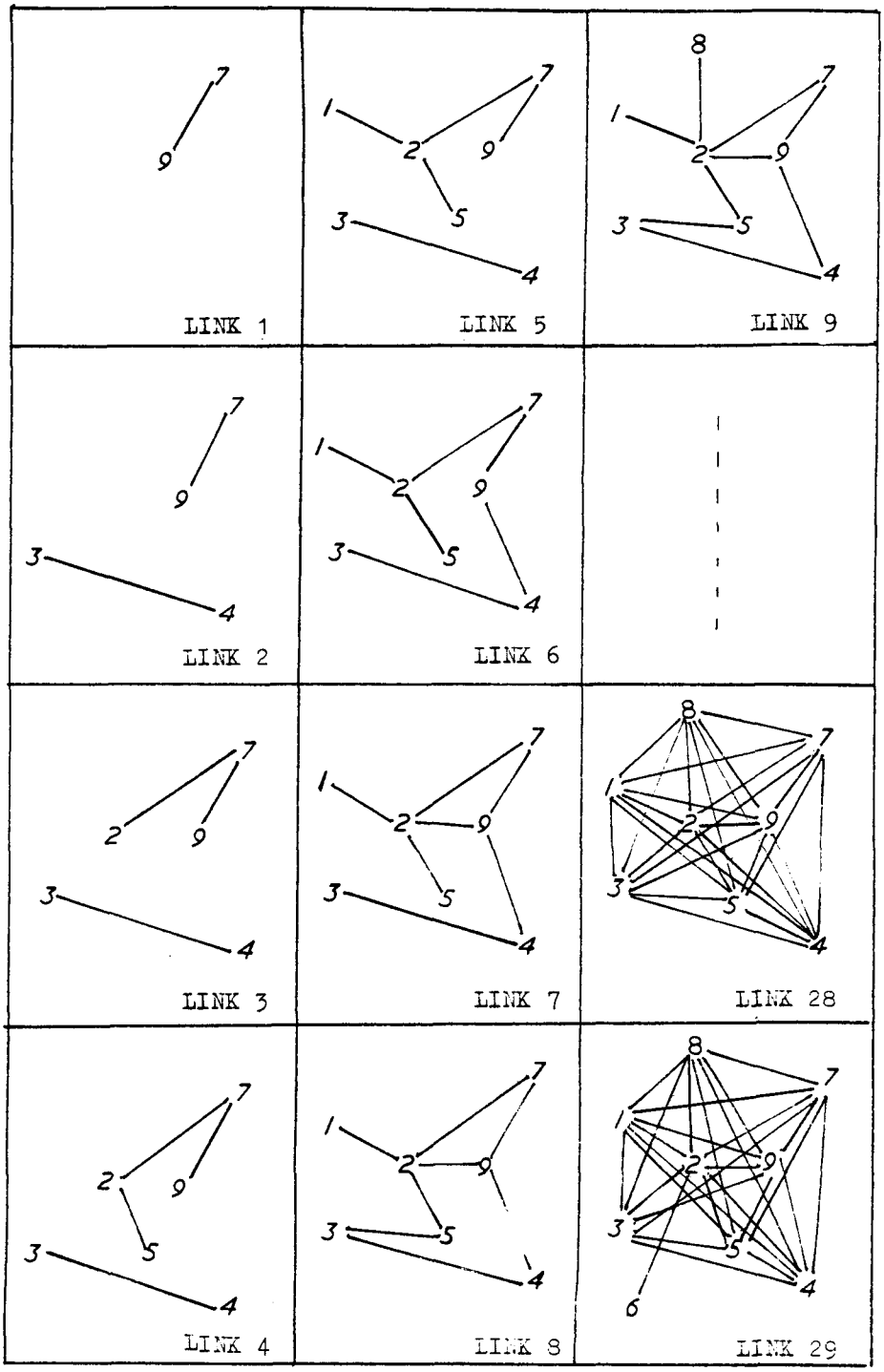


FIGURE 4 SOCIOGRIDS Analysis of Relations Between Participants

These techniques therefore offer a method for investigating the sharing and overlap of construct systems used to enter world 3's as shown in Figure 1. The socionets can be used to identify the position of the intersecting space and the mode grid may be used to indicate the content of it. These programs have been applied to a wide variety of situations (Shaw 1980a) including industrial inspection of knitwear, appraisal of subordinates and interactions in groups of students. They can be used to chart changes in the attitudes in a group over a period of time, and to investigate alternative points of view which may lead to a conflict of interests. It has been our experience that participants in such an exercise become very involved in the process of reviewing similarities and negotiating differences within the group, and find it a relevant learning experience. In Grey's (1979) terminology the programs provide a relevant nurturing environment for the emotionally charged experience of coming to terms consciously with other P-Individuals and their worlds.

CONCLUSIONS

This paper has sketched out theoretical foundations for integrating the conventionalist model of personal knowledge proposed by Kelly and developed in our previous papers with the normative model of knowledge structures in Popper's theory of "3 worlds". It gives the beginnings of an account of how "personal scientists" interact with the "real world" and with one another to form "communities of science". It is has shown how the interplay between these two epistemologies leads to the formation of Pask's P-Individuals who in Wolff's terminology surrender themselves to world 3 in order to catch its essence and linked this to Grey's emotional-cognitive theory of the system forming precursors to construct formation. It also again emphasizes the role of the computer as a tool with which to explore the construct spaces formed through the existence of world 3s, and hence to explore these worlds themselves.

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