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Elicitation Techniques for Classification Research
Ordered Trees, Repertory Grids, and Q-Sort Methodology

David Dubin
Department of Information Science
University of Pittsburgh
Pittsburgh, PA 15260
dsdst3@lis.pitt.edu

Barbara H. Kwasnik
Chatpong Tangmanee
School of Information Studies
Syracuse University
Syracuse, NY 13244
bkwasnik@mailbox.syr.edu
ctangman@mailbox.syr.edu

One of the greatest challenges in this field is designing studies that can shed light on the cognitive processes of classification. The reason that this is so difficult is that many of these processes are implicit. People act on classifictory decisions without being aware of them. The papers in this three-part section address different techniques that can be used to elicit information about how people order and cluster phenomena. The techniques discussed are: Ordered Trees, Repertory Grids, and Q-Sorts. Each section will describe the origin of the technique and its past and potential applications. The use of the technique will be illustrated by examples from hypothetical cases or from actual ongoing research projects.

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Elicitation Techniques for Classification Research: Part I. Ordered Tress

David Dubin

The ordered-tree algorithm is a tool for revealing the organization of information in linear orders. It is based on the premise that complexly organized items are grouped in discrete "chunks," and that subjects process all the elements of one chunk before proceeding to the next. Input to the ordered-tree algorithm is a set of strings, some of which are completely free and others which may be cued by items from the set. Output from the algorithm is a hierarchical tree in which items consistently ordered together are grouped in a subtree. Ordering of the tree branches reflect constraints on the order in which items were processed. This algorithm is sensitive to errors, since it models regularities across the entire set of strings. A "jackknifing" procedure detects outliers in the input data which may indicate omissions or errors. The number of possible traversals of an ordered-tree provides a basis for measuring its complexity or amount of organization. The ordered-tree algorithm has been applied in the study of spatial memory and expert/novice differences in knowledge organization.

INTRODUCTION

This paper describes a method of learning about how people order and organize phenomena. That method is the ordered tree algorithm, which was first developed by Judith Reitman and Henry Rueter (Reitman and Rueter, 1980). The input to this tool are strings of tokens that have been ordered by subjects. The output is a tree structure that models the order constraints consistent to those strings. In the next section a simple example demonstrates the relationships which ordered trees reveal. Following that are several examples of how ordered trees have been used in psychological and educational research. Finally, some suggestions are offered for readers who may wish to use ordered trees in their own research.

ORGANIZATION IN ORDER

In classical mythology, the muses were daughters of Mnemosyne (memory). Can you remember the names of all nine? If you can, then the order in which you recite the names might tell us something about the strategy you use to remember them. For example, asked to recite the names four times, a person might consistently recall them in the following order:

1. Calliope (epic)
2. Clio (history)
3. Erato (love poetry)
4. Euterpe (music)
5. Melpomene (tragedy)
6. Polyhymnia (hymns)
7. Terpsichore (dance)
8. Thalia (comedy)
9. Urania (astronomy)

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That would suggest the person was using an alphabetic mnemonic. Completely consistent ordering might reveal some other trick like an acronym or mnemonic phrase. But free recall data can reveal organization of the names in memory even if the order isn't completely stereotyped. Suppose a person recalls the names in these orders:

- Er Me Th Te Eu Ur Po Ca Cl
- Ca Cl Er Eu Te Me Th Po Ur
- Me Th Eu Te Ur Po Ca Cl Er
- Eu Te Me Th Po Ur Er Ca Cl

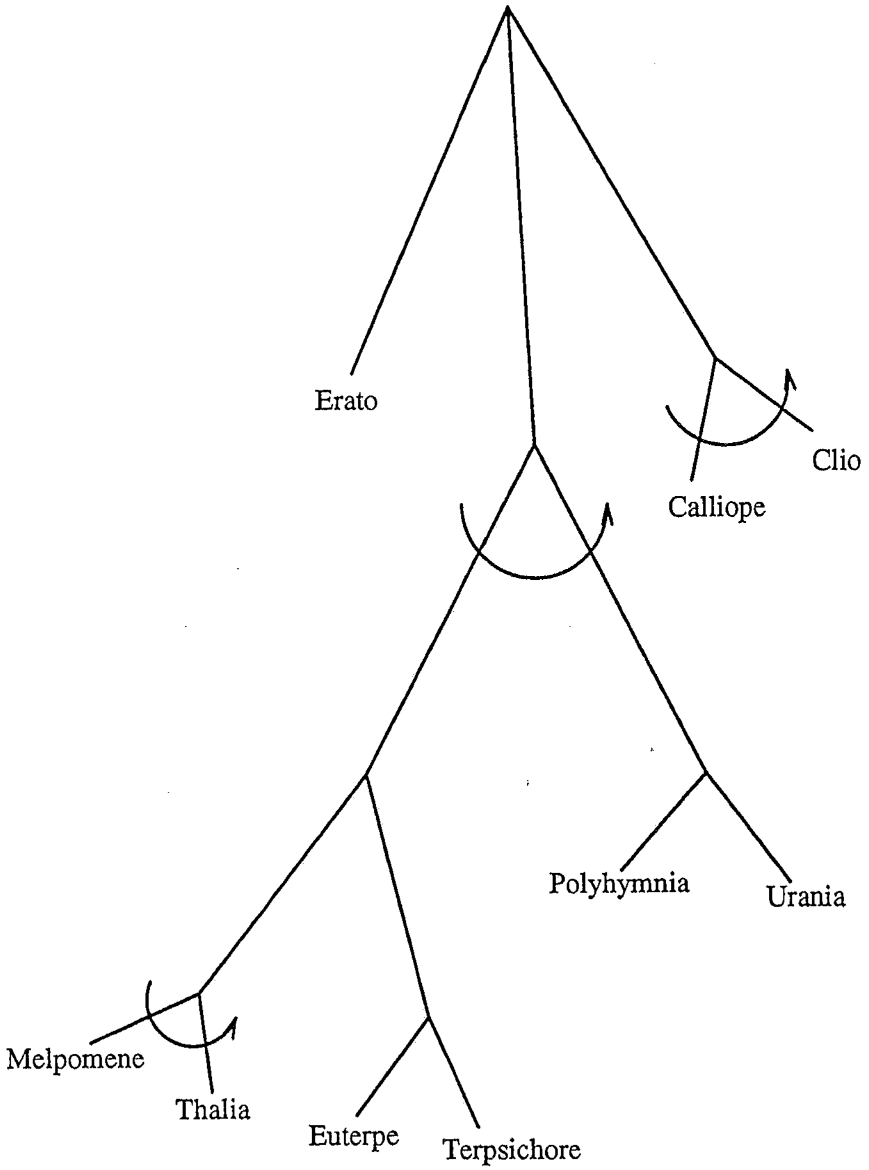

Figure 1: Ordered tree from recall of muses' names

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Four trials may be too few on which to base conclusions, but patterns already begin to emerge. At the lowest level, the names seem to be recalled in pairs, with some (e.g. Calliope and Clio) in a fixed order, while others (like Urania and Polyhymnia) are recited in either order. There may also be organization at higher levels. Erato, for example, though recalled once at the beginning, one at the end and twice in the middle, is not recalled in the midst of Terpsichore, Euterpe, Melpomene, and Thalia, who are consistently recalled together. In all three trials Polyhymnia and Urania are recalled right after that group of four.

Figure 1 shows output from the ordered tree algorithm applied to the four trials listed above. The algorithm identifies all regularities in the ordering of information, under the assumption that the information is organized in discrete "chunks," that are "visited" in turn. Items in free recall strings, for example, represent data chunked together in human memory. The assumption is made that all items in one chunk are recalled before items in any other chunk.

The tree in Figure 1 suggests that the names of the muses are organized in seven chunks in the memory of the person who produced the recall strings. The top-level chunk includes all nine names, and consists of three lower level chunks. Erato is alone in one chunk, the pair of Calliope and Clio form the second, while the remaining six make up the third chunk. That chunk consists of one chunk of two names, and one chunk of four (which can be further divided into two recognizable chunks of two names each).

The ordered tree algorithm can recognize three kinds of chunks: unidirectional, bidirectional, and nondirectional. The contents of a nondirectional chunk (such as the top-level chunk in Figures 1) can be accessed in any order. A unidirectional chunk (such as the Melpomene and Thalia pair) can be accessed only in a fixed order. A bidirectional chunk can be accessed in a single order or its reverse. Recall strings consistent with an ordered tree result from any depth-first traversal from the root through each of the leaves, as long as the ordering constraints are respected. For example, in strings consistent with the tree in Figure 1, Urania may precede Polyhymnia, but never Euterpe.

Ordered trees reveal a kind of organization that is difficult to model using tools based on psychological distances such as hierarchical cluster analysis and multidimensional scaling (MDS) (Manly, 1986). In a clustering or MDS study, one might examine the average number of tokens which separate a pair of items in the recall strings. Those proximities could be modeled with a hierarchical tree (using clustering methods) or with points in a plane (using MDS). However, hierarchical clustering and MDS may hide relationships if proximities are asymmetric (Kruskal and Wish, 1988). One often finds asymmetric distances between ordered pairs in free recall. Looking back at the recall strings in the first example, Clio always follows directly after Calliope, but after Clio, there will likely to be many names recited before Calliope is again recalled (during the following trial). Ordered trees make that information explicit.

USE OF ORDERED TREES IN EXPERIMENTAL RESEARCH

In typical ordered trees experiments, subjects order items by reciting them from memory. For example, (Reitman and Rueter, 1980) describes an experiment in which expert and novice programmers memorized and recalled reserved words in a programming language, and the experimenters generated ordered trees from subjects' recall of those key words. Experts' trees

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showed they grouped words according to meaning and function (e.g. by the chunking together of terms relating to data structures or those relating to control logic). Novice subjects produced trees that were just as organized as the experts, but chunks appeared to be based on natural language associations. Experts trees were more similar to each other than were those produced by novices.

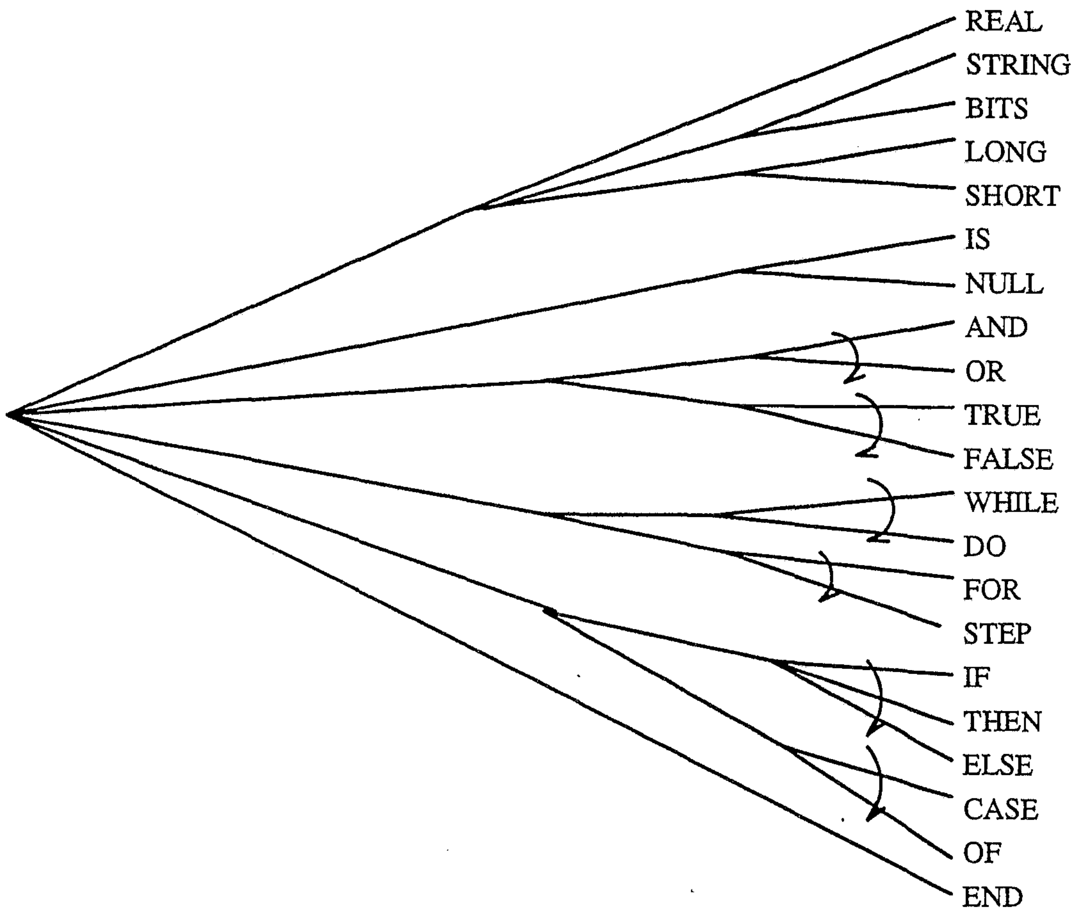

Figure 2: From (Reitman and Rueter, 1980): expert's organization of reserved words.

In a study by (McNamara et. al., 1989) subjects memorized the locations of objects on spatial layouts and maps, and ordered trees were produced from free and cued recall of the objects. Locations of the objects on the layouts and maps were evenly distributed, but the ordered trees showed subjects recalling clusters of objects near each other. Some clusters were nested hierarchically. The ordered tree analysis (together with spatial priming and distance estimation data) provided evidence in support of hierarchical theories of spatial memory.

Not all ordered tree studies have subjects recall verbal or spatial data from memory. In (Naveh-Benjamin, et. al., 1986) subjects (psychology students) were shown key words representing concepts to be covered in the class, and instructed to order the words in a list so that related words

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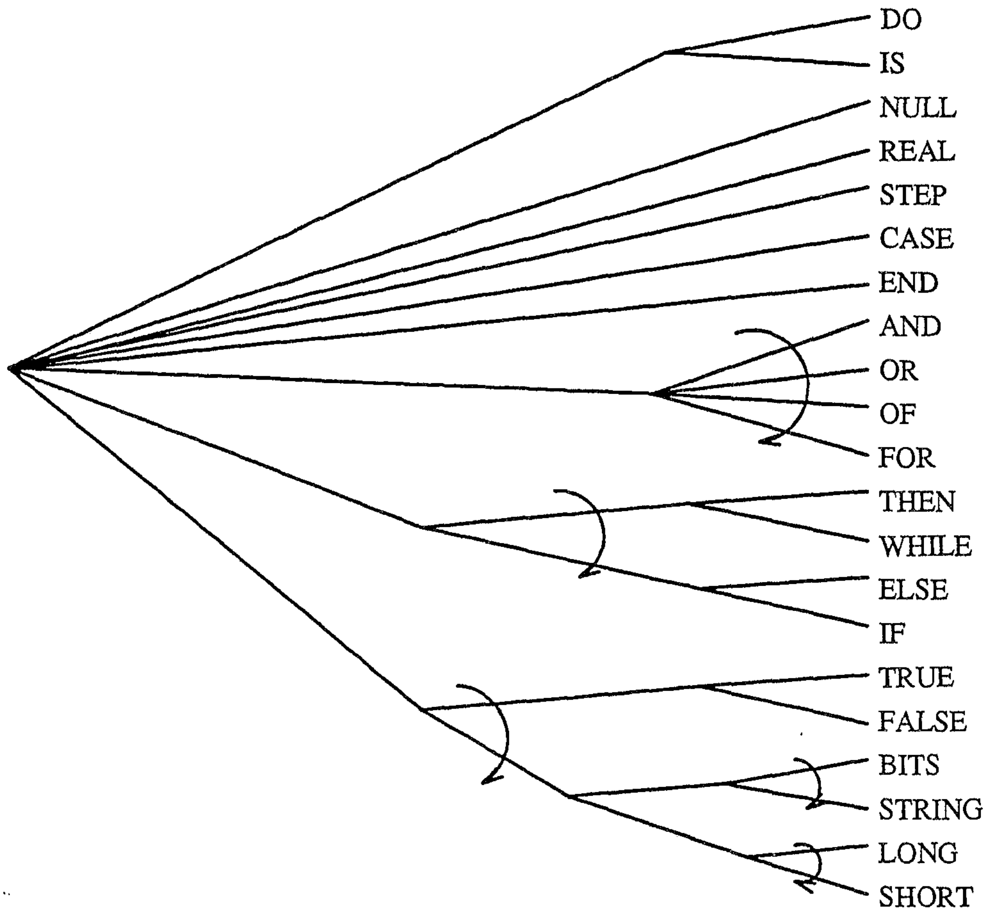

Figure 3: From (Reitman and Rueter, 1980): novice's organization of reserved words

would be near each other. The investigators found that ordered tree organization and similarity to the instructor's tree were correlated with academic performance. Better students had more organized trees, and shared more chunks in common with the instructor's trees. Greater organization only helped when the students' organization was similar to the instructor's. Good students' trees showed more ordered relations than those of poorer students. In a second experiment, subjects completed the same ordering task at the beginning, middle, and end of the course. The investigators found that as the course progressed, strong students' trees became more organized and more similar to the instructor's.

At the 1992 SIG-CR Workshop, (Hirtle and Ghiselli-Crippa, 1992) suggest that ordered trees (or a map path graph representation they propose) could model the structure of a document collection based on the orders in which people examine documents while browsing or searching online. But as the authors show in their example, people browsing a large collection won't look at exactly the same fixed set of documents. For that reason, data would have to be collected under experimental

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conditions, or else analysis would have to be limited to that subset of the collection browsed by all subjects.

USING ORDERED TREES

What exactly does an ordered tree reveal about the organization of data or phenomena? What can one say about a specific ordered tree? Some of the studies reviewed in the last section are concerned with the amount of organization or structure in a tree. For example, Figure 4 shows a tree which (Naveh-Benjamin, et. al., 1986) concluded had little organization, while the tree in Figure 5 is more structured. How does one know when a tree is highly structured, and how is it possible to measure the amount of organization?

Counting the number of traversals possible in (or recall strings consistent with) an ordered tree is one way of characterizing how organized the chunks or clusters are. If items can be recalled in any order, then one can say that they have no organization. If on the other hand there are few (or only one) possible order, then the items must be highly organized. The PRO (possible recall orders) of a tree is the natural logarithm of the number of recall orders consistent with it (Reitman and Rueter, 1980). For example, there are 48 traversals of the tree in Figure 1 consistent with the ordering constraints. So the PRO of that tree is 3.8712.

Since an ordered tree models all order constraints in the recall strings (and only those constraints), it's important that the recall strings represent the variety of orders that are possible. For example,

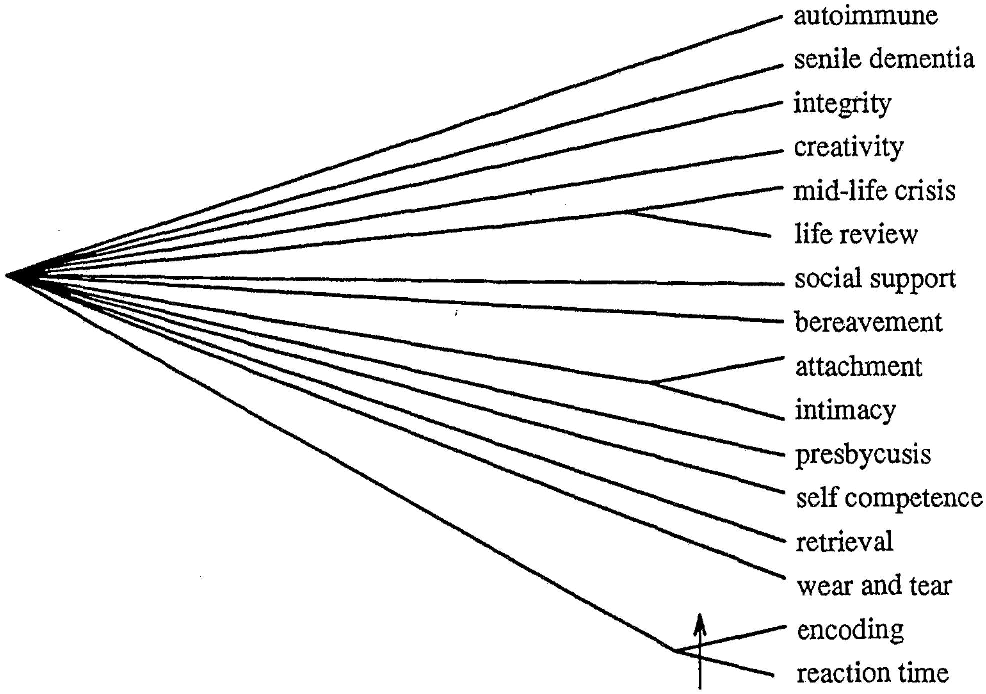

Figure 4: From (Naveh-Benjamin, et al., 1986): a tree with little organization

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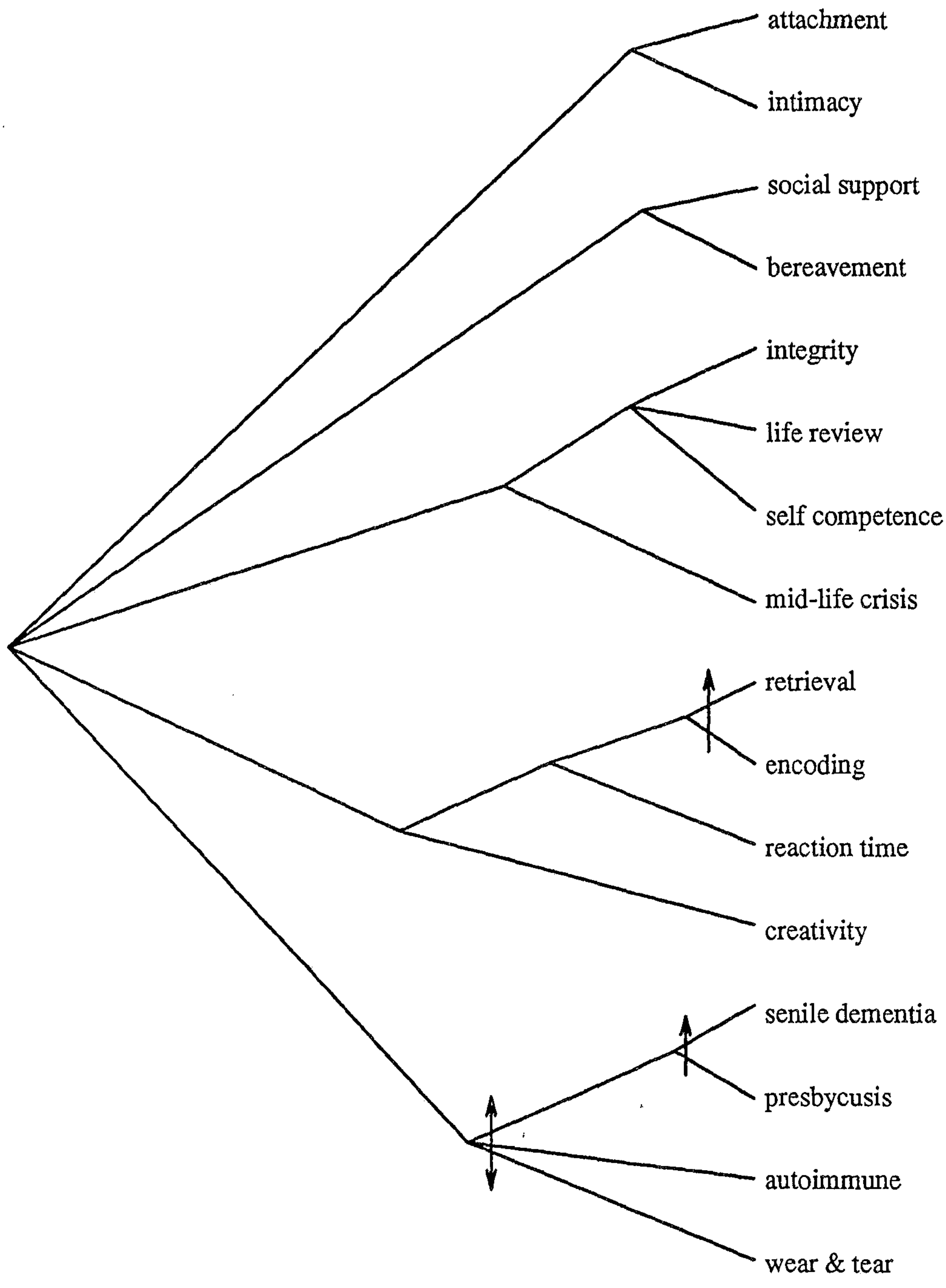

Figure 5: From (Naveh-Benjamin, et al., 1986): a tree with greater organization

if a subject always recalls items in exactly the same order, it may have more to do with habit than the amount of organization in the subject's memory. A true picture of that organization requires a sample of recall strings representative of all those that are possible. To encourage variety, experimenters using ordered trees will often "cue" subjects with one item from the list. Going back to the first example, one might give subjects the name of one muse, and ask that they recall the

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names of the others. Recall strings from cued trials are tagged prior to analysis, and the ordered tree algorithm ensures that the effects of cueing do not erroneously affect the structure of the tree (Reitman and Rueter, 1980).

Subjects are typically tape-recorded in experiments involving recall of data from memory; experiments with ordering or exploration tasks require some other instrument for recording subjects' behavior. The ordered tree algorithm is sensitive to errors, since it models regularities across the entire set of recall orders. Reitman and Rueter describe a "jackknifing" procedure for detecting outliers in the input data which may indicate omissions or errors. If excluding a trial from the input set produces a tree with significantly lower PRO (i.e. much more organized) then that trial is considered an outlier and excluded from the final analysis (Reitman and Rueter, 1980).

It's important to remember that greater "organization" (as measured by PRO) does not necessarily imply greater sophistication. For example, a rote memorization strategy can lead to stereotyped recall, and produce a tree with only one traversal possible. But that kind of structure will almost certainly be less interesting than one which affords a number of different recall orders.

Researchers interested in obtaining a FORTRAN implementation of the ordered tree algorithm may contact Professor Stephen Hirtle at the University of Pittsburgh's Dept. of Information Science (email: sch@lis.pitt.edu).

CONCLUSIONS

One may gain insight into the structure of mental classifications by observing how the categories influence the ordering of tasks. Knowledge organization studies in education research[1] and studies of expert/novice differences[2] account for much of the ordered tree applications published in the last few years. But any situation where the order in which things are retrieved, examined, visited, or recognized may reveal structure in the data itself (or in the retrieval/ examination process) might employ a tool like ordered trees.

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1. e.g., (Winitzky, 1992)
2. See also (McKeithen, et al., 1981).

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Elicitation Techniques for Classification Research: Part II. Repertory Grids

Barbara H. Kwasnik

The concept behind repertory grids (based on Kelly's personal construct theory) is that people's conceptual structures are characterized by the distinctions they make among significant elements in their domains of knowledge and experience. These distinctions are often implicit and are difficult to elicit using ordinary techniques of sorting and observation. Repgrid elicitation is a technique (really a structured interview (Fransella & Bannister, 1977) of sorts) that allows implicit distinctions and similarities to be made explicit. In repgrid technique, the phenomena of interests are called "elements" while the criteria by which people distinguish the elements are called "constructs." Respondents make comparisons among elements based on differences and similarities that are elicited during the process of building the grids. The results display clusters of entities and constructs that give a picture of how an individual construes those entities. The intermediate outcome of repertory grid technique is a two-way classification of data consisting of a matrix of elements and the personal constructs pertaining to those elements. The grid can then be analyzed to show clusters of elements, constructs, and elements and constructs with respect to each other. Grids are constructed for individuals, but they can also be compared among individuals to see how similarly or differently the individuals categorize entities.

INTRODUCTION

George Kelly (1955; 1970) developed Personal Construct Theory in which he argued, among other things, that people's conceptual structures are characterized by the distinctions they make among significant elements in their domains of knowledge and experience. As a tool for discovering and uncovering such personal constructs, he developed a method called repertory grid technique. Using this technique, grids are elicited from individuals by asking them to talk about similarities and differences among phenomena of interest (called *elements*). In talking about the similarities and differences (called *constructs*) the individuals are allowed to use their own words and their own rules for what constitutes a distinction. In other words, repgrids are a way of exploring a person's or group of people's system of cross-reference between personal observations of the world and their personal constructs or classifications (Shaw & Gaines, 1989).

ELICITATION OF GRIDS

As mentioned above, repgrid technique is marked by two important characteristics: 1) the elicitation from individuals of similarities and differences among some elements of interest, and 2) the ability of respondents to use their own words in articulating the distinctions. Whether the researcher is using a manual or computer-assisted method, the following steps are common to all repgrid elicitations:

1. First, it is necessary to ***compile a list of elements***. Depending on the context, the elements can be supplied by the researcher, or elicited from the respondent. Elements are entities (people, things, situations, places, etc.) that are of interest given the nature of the situation. So, for example, a therapist might ask the patient, "Name some important people in your life." The patient replies, "Well, there's my teacher, my mother and father; and my girlfriend, and oh yes, my brother, and — uh, my probation officer."

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2. Once this list is compiled (there are practical rather than theoretical limits to the number of elements that can be managed), the elements are used to ***elicit the constructs.*** Constructs are concepts that are associated with the elements. The best constructs are those that define the elements for the individual by describing those aspects that are salient in terms of the *meaning* of the elements for that individual. For a given group of students, for instance, we might say that they can be distinguished by being either *blue-eyed* or *dark-eyed.* Such a distinction, however, might be *accurate*, but not very *important.* Perhaps such a distinction is trivial, or perhaps it does not get at the critical dimensions along which it is useful to distinguish students. In repgrid technique the aim is to elicit important and meaningful distinctions that will shed some light on underlying (and often implicit) classifications. At the same time, it is important that the distinctions be those that are true for the individual rather than those suggested by a researcher or anyone else.

   There is a number of ways to elicit constructs, but the most common technique is to present the elements in pairs or triads and to ask the respondent to think of ways in which the presented elements are similar and different. So, in following the previous example, the therapist presents the patient with three elements: *father, mother*, and *teacher,* and asks,
   — "Which one is different from the other two?"
   The patient answers:
   — "Hmm, I guess my father is different from my mother and my teacher."
   — "Describe one important way in which your mother and your teacher are similar?" continues the therapist.
   — "Well, my mother and my teacher are both *bossy....*"
   — "And in that respect, how is your father different?" asks the therapist.
   — "Oh, he is much more *flexible."*

   In this case, *bossy* and *flexible* now become constructs. They are concepts that seem to be meaningful in terms of important people in this individual's life. In repgrid technique the constructs are always expressed in pairs, as opposite poles (to maximize the perception of difference as well as similarity). Thus, when we speak of *constructs*, we are really speaking of *construct-pairs*, but for brevity they are referred to as just constructs. It is also clear that for many of us, *bossy/flexible* may not be construed as opposites, but in repgrid technique, the respondent is allowed to construct his or her own rules for what constitutes a distinction so long as it is meaningful to him or her.

3. Next, all the other ***elements are rated using the elicited construct-pair.*** So, in this case, the remaining three elements, the *girlfriend, brother,* and *probation officer* are rated as either *bossy* or *flexible.*

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4. The steps are repeated until the respondent can think of no other meaningful ways of expressing distinctions and similarities. During the construct-elicitation process, the elements can be presented randomly in triads or pairs, or in some more structured way. Typically, triads are presented randomly until the constructs are not so readily forthcoming. Then the researcher may present selected elements that continue to yield meaningful comparisons. As each construct-pair is elicited, the other elements are also rated against it. The ***result is a grid*** — a two-by-two matrix of elements and constructs. By way of illustration, let us say the patient of our example expressed the following (with X's referring to the top half of the construct-pairs and the O's referring to the bottom half):

	CONSTRUCTS				
	Bossy	**Loving**	**Talkative**	**Sensitive**	**"With it"**
1. Teacher	X	O	X	O	O
2. Mother	X	O	X	O	X
3. Father	O	X	O	X	X
4. Girlfriend	O	X	X	X	X
5. Brother	O	O	O	O	O
6. Probation Officer	X	O	X	O	O
	Flexible	**Stern**	**Quiet**	**Insensitive**	**Old-fashioned**

Table 1: Illustration of a Repertory Grid with 6 Elements and 5 Construct-Pairs

5. The next step is to analyze the grid. This process, when done manually, involves searching the grid for patterns among the elements and also among the constructs. Thus, for this grid, we see that in terms of the elements, the patient's *teacher, mother,* and *probation officer* are perceived as similar, that is, each is rated similarly in terms of the construct-pairs. In fact, these three people are perceived as *exactly the same (bossy, stern, talkative,* and *insensitive),* except for one dimension: the mother is perceived as *"with it,"* while the other two are not. In the same way, the *father* and *girlfriend* are perceived as similar, except in terms of being *talkative/quiet*. In terms of the constructs, people who are *loving* are also seen as *sensitive*; people who are *stern* are also seen as *insensitive*. People who are *loving/sensitive* tend to also be perceived as *"with it,"* while people who are *stern/insensitive*, tend to also be seen as *old-fashioned.*

Repertory grids are not used as a test or a metric. In clinical situations, such a grid would be used as a catalyst for further discussion and insight. In research situations, grids have heuristic value in showing areas of agreement and disagreement, but are not "proofs." Their strength is in revealing

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similarities and differences that might not otherwise be obvious, that is, making explicit that which is implicit.

In this way, repgrids are really a structured way of listening. The respondent's attention is focussed to relatively narrow comparisons which allows him or her to build up a picture incrementally rather than having to express it all at once. In addition, grids can show subtle differences among elements that might not present themselves readily when there are large areas of similarity. In the example, it might be significant that although the patient's *mother* is perceived as similar in most respects to the patient's *teacher* and *probation officer*, the one difference of being perceived as *with it* rather than *old-fashioned* might be crucial in explaining behavior or attitude. That is, repgrids are sometimes useful in pinpointing critical differences. This is so because Personal Construct Theory, on which repgrids are based, posits that individuals build up their perspectives or ways of looking at things in a multi-dimensional way. Each entity is perceived along a number of dimensions (constructs) rather than along only one.

AN ILLUSTRATION OF A REPGRID APPLICATION

For the purpose of illustration, a small study was conducted to explore the application of repgrid technique to thesaurus maintenance,[1] specifically to the introduction of new terms into a thesaurus. Why might repgrids be useful? In updating a thesaurus with a new term it is necessary to:

- determine whether the new term is synonymous or nearly synonymous with already existing terms;
- determine if there is consensus among experts in the use and definition of the term;
- find a place within the thesaurus structure for the new term; and
- establish the syndetic links from the new term to other terms.

If we examine these tasks, it becomes evident that several of them address the fact that terms are subject to a variety of interpretations and usage, that is, they are construed differently from one person to another. Such differences might lead to a variety of perceptions of where a new term "fits" within the thesaural structure. It was the premise of this study that repgrids might be helpful in defining how terms were construed and also in pinpointing areas of disagreement.

PROCEDURES

1. A **hypothetical situation was constructed.** Suppose we wanted to add the terms

Jacuzzi
Hot tub
Whirlpool

to a thesaurus like the *Art and Architecture Thesaurus.* These terms do not presently exist in the thesaurus, but there are some candidate spots into which they might fit. First of all, we need to establish if these terms are synonymous with existing terms or with each other. Next we would need consensus on their use. Finally we need some guidance in where within the conceptual structure of the thesaurus each of these three terms might fit.

1. This study was presented in a different form at the 1991 ASIS Mid-Year Meeting, Santa Clara, CA, April 26-29, 1991.

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2. For the purpose of establishing synonymy and conceptual affinity, the thesaurus was searched (by the researcher) for the possible sections into which the three terms might fit, and for other terms to which they might possibly be related by syndetic links. In fact, there were at least four such candidate sections: Under **"Built Environment,"** jacuzzis, hot tubs and whirlpools could possibly fit under **"Bath, Dressing & Sanitary Spaces"** (shown in Fig. 1), **"Mechanical Systems — Plumbing Fixtures,"** or **"Water Recreation Structures."** Under the **"Furnishings & Equipment,"** section, jacuzzis, hot tubs and whirlpools could possibly fit under **"Hardware by Location or Context."** In other words, these three elements could possibly be construed as a place, as fixtures, or as hardware.

[R] BUILT ENVIRONMENT
- [RM] BUILDING DIVISIONS AND SITE ELEMENTS
  - BUILDING DIVISIONS
    - ROOMS AND SPACES
      - ROOMS AND SPACES BY FUNCTION
        - BATH, DRESSING & SANITARY SPACES
          - BATHROOMS
          - DRESSING ROOMS
          - LAVATORIES (ROOMS)
          - LOCKER ROOMS
          - PRIVIES
          - REST ROOMS
          - SAUNAS
          - SHOWER STALLS
          - STEAM ROOMS
          - TOILET COMPARTMENTS

Fig. 1. An excerpt from the *Art & Architecture Thesaurus* "Built Environment" section under which jacuzzis, hot tubs, and whirlpools might fit.

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3. The four sections of the thesaurus that had been identified as candidate locations for the inclusion of the update terms were then searched (by the researcher) for **conceptually related terms.** The existing and new terms were combined into a list of 13 elements:

TERMS NOT ALREADY IN THE THESAURUS

jacuzzis	**hot tubs**
whirlpools	

CONCEPTUALLY RELATED TERMS ALREADY IN THE THESAURUS

bathroom hardware	**plumbing hardware**
saunas	**pools**
swimming pools	**steam baths**
tubs	**baths**
bathtubs	**bathrooms**

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4. Next, five **respondents were chosen** from among the researcher's colleagues. In a real-life situation, where the terms were actually being added to the thesaurus, the respondents should have been "experts" on architecture and architectural terms, but this was an imaginary scenario.

5. An individual **repgrid was elicited** from each respondent. In this study, instead of eliciting the elements from each respondent, the elements were supplied by the researcher.[1]

   Fig. 2 shows the process of rating the elements on the construct-pair *private context/public context*. In RepGrid2, when the respondent has identified one element to be different from the other two in the triad, the program asks for the constructs that describe the distinction (in this case *private context* vs. *public context)*. Once the constructs have been supplied, the program presents them as opposite ends of a pole, as in Fig. 2. The respondent then drags the other elements by means of a mouse, and places the element somewhere along the continuum between *"private context"* and *"public context."*

   In traditional manual methods of grid elicitation, a respondent had to make binary decisions about how a given element was construed with respect to a given construct-pair. That is, each cell of the matrix had one of only two values. In RepGrid2, the researcher can set the values from 2 to many. The default is 9, and this is what is shown in the figures presented here. That is, in making a decision about whether a *steam bath*, for instance, is thought of as more public or private, the respondent is not forced to choose either extreme, but can choose on a scale of 1 to 9, with each end of the pole having a value of 1 and 9, and the intervening space on the continuum being divided into 7 steps. The respondent is not made aware of the numerical values. Instead, he or she visually places the element on the construct-pair continuum.

   In Fig. 2, the respondent has moved some of the elements away from the extreme poles. In this illustration it can be interpreted as, "Steam *baths* are far more *public* than are *bathtubs*, but there can be something even more *public*." The respondent can manipulate the elements until he or she is satisfied with the relative placement of all of the elements. He or she can also change the wording of the constructs in the event that they no longer seem appropriate. In addition, the respondent has the option of saying "Neither" or "Both." In this case, the respondent has decided that *bathroom hardware* and *plumbing hardware* are not meaningfully distinguished by the construct-pair *private context/public context.* The five elements in a list on the far left of Fig. 2 are awaiting a rating using this particular construct-pair.

---

1. In the patient/therapist example, presented earlier, the repgrid was elicited manually and analyzed by "eyeballing," In the study being described in this section, the process of construct elicitation, generation of grids, grid analysis, and inter-grid analysis was accomplished with the aid of RepGrid 2, a system of tools for Macintosh computers designed at the Centre for Person-Computer Studies, Calgary, Alberta. This software was designed for knowledge elicitation for expert systems, and was meant to be self-administered. The software not only enables easy and flexible manipulation of elements and constructs, but also performs instant principal components analysis on the grid. The outcome are grids and also graphical displays of element and construct clusters. In addition this software allows the researcher to compare grids among individuals in order to identify areas of agreement and disagreement in their construing of elements.

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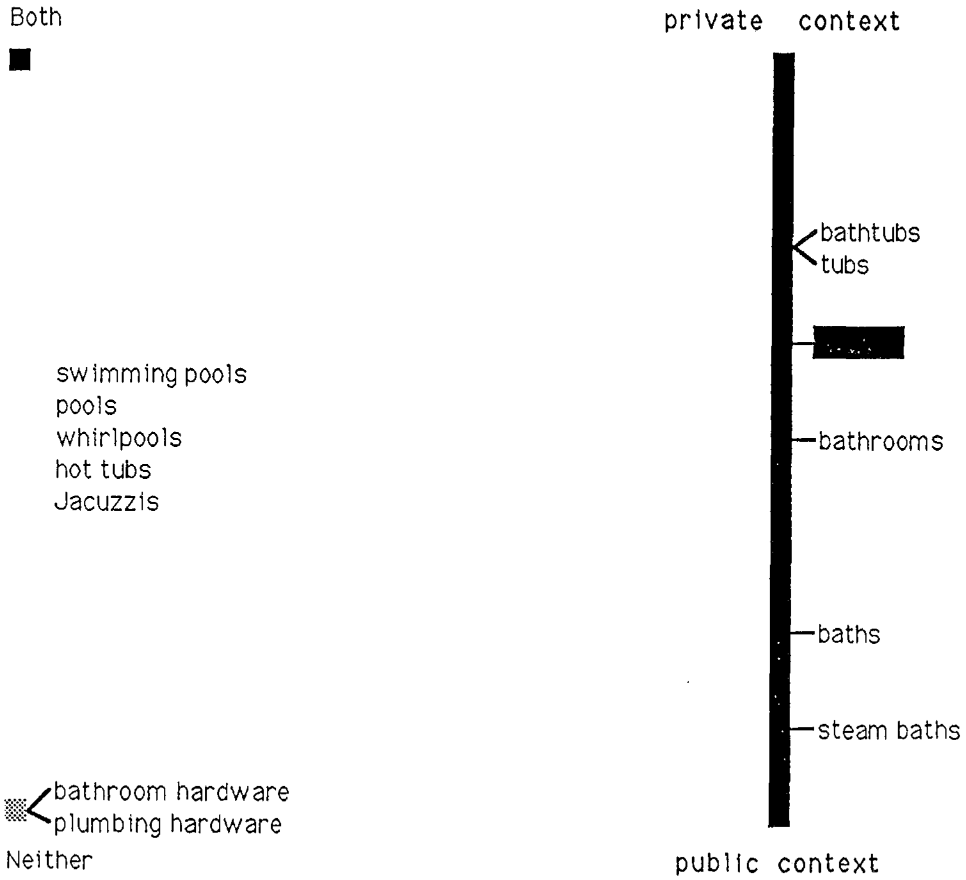

Fig. 2. One individual's rating of elements on the construct pair *private context/public context.*

6. Once an individual can no longer think of any meaningful constructs by which to distinguish the elements, and once all the elements have been rated using all the constructs, the preliminary elicitation process is complete. At this point it is possible to generate several graphical displays of the results. The first is what is called a **"raw" grid** (as shown in Figure 3. A raw grid has translated the positioning of the elements on the construct-pair continua into values from 1 to 9. Mike's grid (Fig. 3) shows that he perceives that, for instance, five elements have a very extreme rating (9) on "no *moving water" — bathrooms, steam baths, swimming pools, pools,* and *saunas*. Three elements have an extreme rating (1) at the opposite pole of *"moving water" — jacuzzis, hot tubs*, and *whirlpools*. Two elements cannot be meaningfully differentiated on this dimension (rating of N) and three others fall somewhere in between (rating of 5). If, on seeing this, Mike thought, "Wait a minute, swimming pools *do* have moving water, sort of..." he could go back and modify his grid accordingly.

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Display: Mike's
Elements: 13, Constructs: 6, Range: 1 to 9, Context: hot tubs

		1	2	3	4	5	6	7	8	9	10	11	12	13		
private context	1	1	1	1	1	9	9	9	5	N	N	5	9	5	1	social context
finished product	2	1	1	1	1	1	1	2	2	9	9	5	2	1	2	component
health and recreation	3	9	9	9	5	5	1	1	5	N	N	1	1	1	3	Hygiene
for private facility	4	1	1	1	1	5	9	9	5	1	1	5	5	5	4	public facility
means to achieve goal	5	9	1	N	1	N	N	N	9	1	1	N	N	N	5	goal
moving water	6	9	5	5	5	9	9	9	9	N	N	1	1	1	6	no moving water

13 Jacuzzis
12 hot tubs
11 whirlpools
10 plumbing hardware
9 bathroom hardware
8 saunas
7 pools
6 swimming pools
5 steam baths
4 tubs
3 baths
2 bathtubs
1 bathrooms

Fig. 3. One respondent's "raw" grid.

7. RepGrid2 also allows the researcher to view what is called a **focussed grid**. A focussed grid has computed similarities and differences among elements and constructs, and places them close to each other in the grid (rather than in the order in which they were generated by the respondent). In some cases the program "flips" the poles of the construct-pairs in order to make similarly functioning constructs appear together. A focussed version of the grid shown in Fig. 3 is presented in Fig. 4.

   In the focussed grid we see that for Mike, *bathroom hardware* and *plumbing hardware* are construed to be identical. That is, they are synonyms as far as he is concerned. He has rated these two elements in the same way using all the constructs. *Pools* and *swimming pools* are almost synonymous except for a slight difference in how they are perceived on the *finished*

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FOCUS: Mike's
Elements: 13, Constructs: 6, Range: 1 to 9, Context: hot tubs

		10	9	4	2	3	1	8	5	6	7	12	13	11		
for private facility	4	1	1	1	1	1	1	5	5	9	9	5	5	5	4	public facility
private context	1	N	N	1	1	1	1	5	9	9	9	9	5	5	1	social context
Hygiene	3	N	N	5	1	1	1	5	5	9	9	9	9	9	3	health and recreation
goal	5	9	9	9	9	N	1	1	N	N	N	N	N	N	5	means to achieve goal
finished product	2	9	9	1	1	1	1	2	1	1	2	2	1	5	2	component
no moving water	6	N	N	5	5	5	1	1	1	1	1	9	9	9	6	moving water

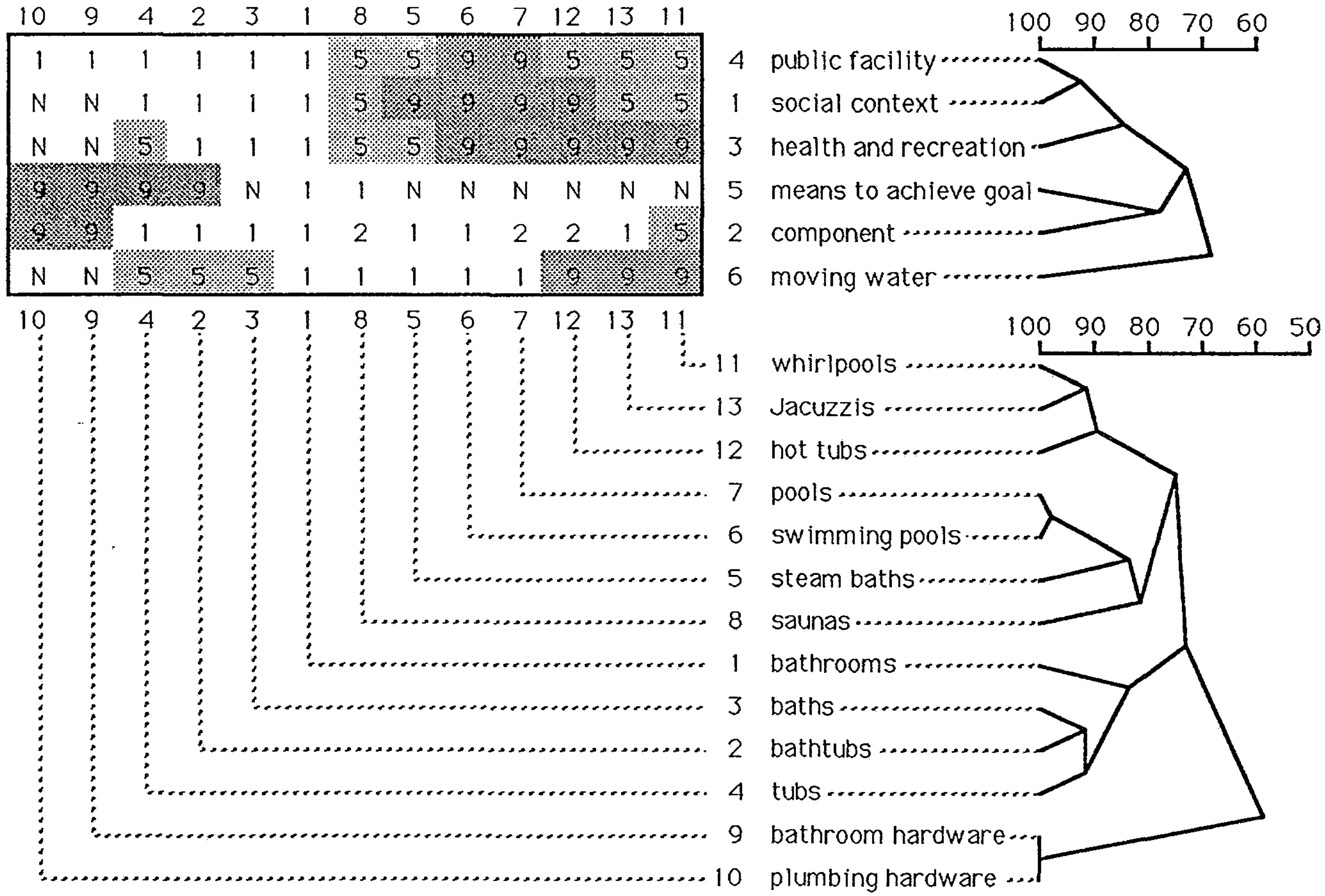

Fig. 4. A focussed grid for one respondent.

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product/component continuum. Upon seeing this focussed grid, Mike might decide that there is in fact no difference between the two and make the adjustment, or, he might decide that the grid suggests even greater differences than he at first perceived. As far as the constructs go, Mike tends to think of elements that are for a *public facility* as also being in more of a *social context*.

8. It is also possible, using RepGrid2, to make **further adjustments** to constructs and elements using two-by-two comparisons of ratings. Fig. 5 shows an example for two elements: *jacuzzis* and *whirlpools*. We see that for this individual they are construed as virtually identical. The vertical lines above the horizontal refer to *jacuzzis*, while the vertical lines below the horizontals refer to *whirlpools*. For the most part, the verticals are congruous with each other. These two elements differ only slightly on three construct-pairs: *still water/ moving water; general/specific;* and *component/finished product.*

If, upon viewing the graph, the respondent wanted to change his mind about these ratings, he could drag the vertical lines to new positions on the horizontal, thereby enhancing the distinctions or similarities even further. Or, he could add new constructs that would differentiate the two elements more precisely.

A similar two-by-two comparison can be made for construct-pairs as well.

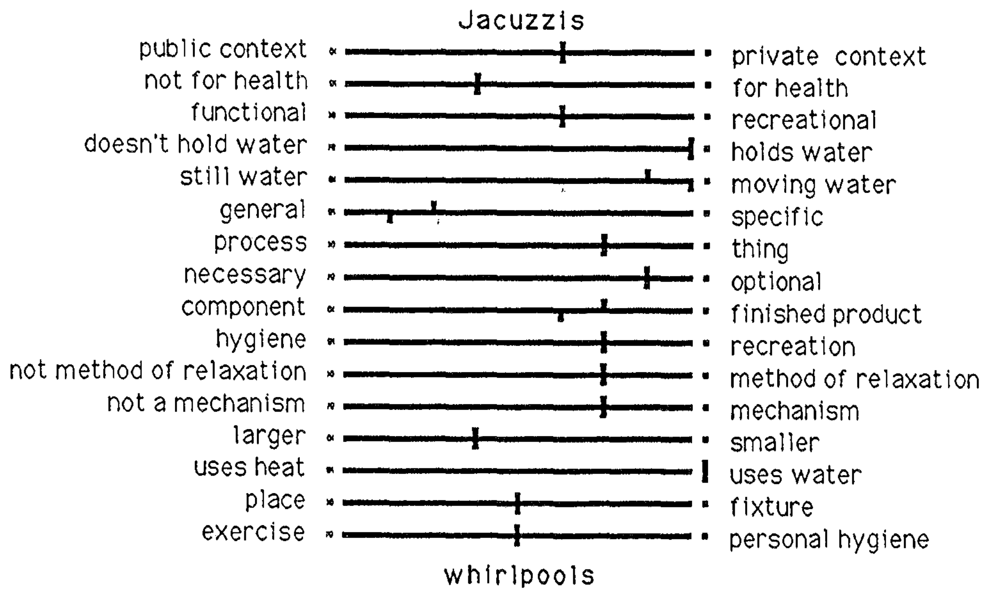

Fig. 5. A graphical display of how two elements have been rated by an individual.

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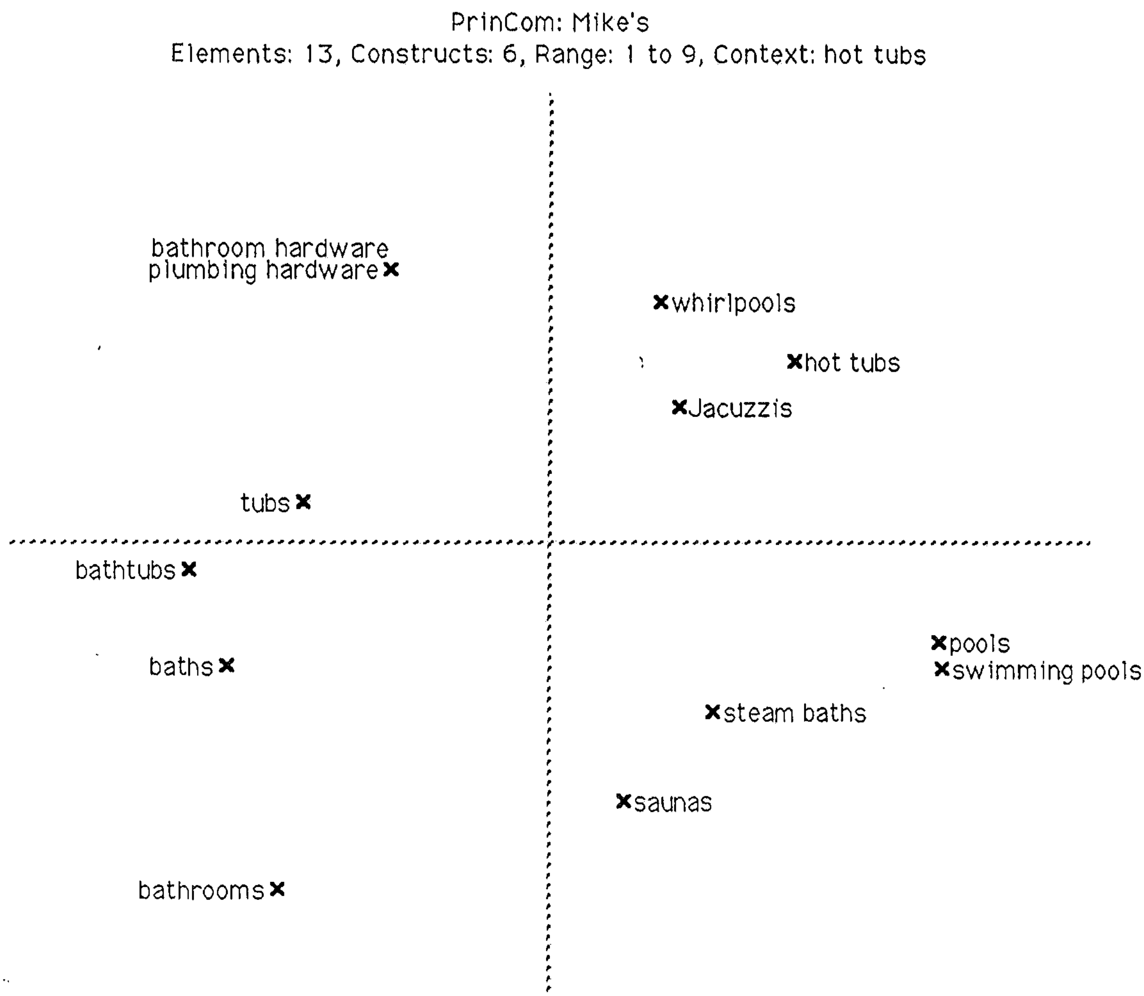

Fig. 6. Principal components graph for one respondent's perception of elements.

9. The program performs principal components analysis on the values elicited from the respondent and translates them into cluster graphs. Fig. 6 shows the graph for the elements as construed by Mike. As his focussed grid showed, *bathroom hardware* and *plumbing hardware* share the same "x" on the graph since they are perceived as identical. *Whirlpools, hot tubs* and *jacuzzis* are close together conceptually, and so on. Fig. 7 shows the corresponding graph for constructs and Fig. 8 the combined graph for constructs and elements for this respondent.

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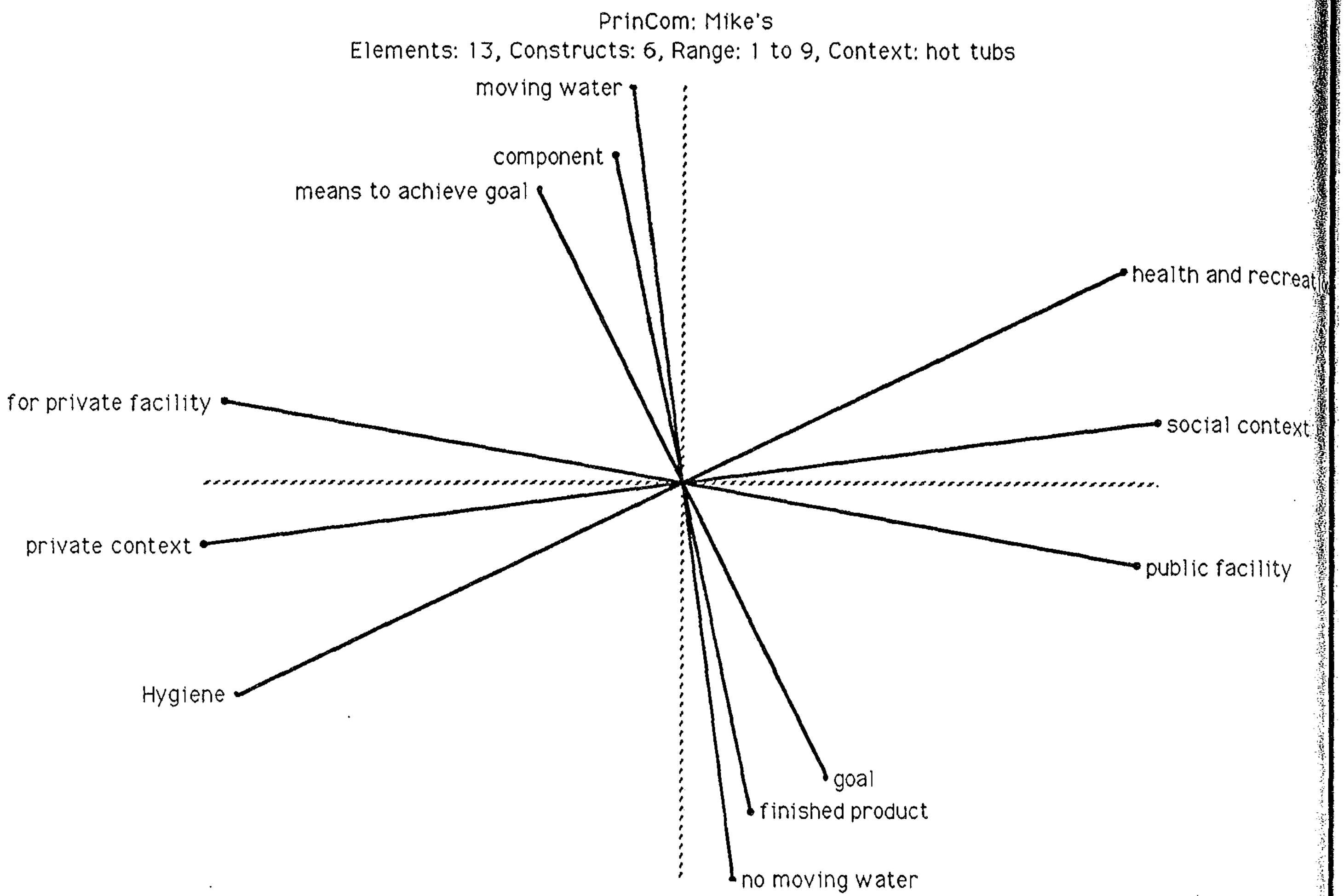

Fig. 7. Principal components graph for one respondent's perception of constructs.

10. Once all five respondents had generated grids, it was clear, just from viewing the displays, that each had construed the elements quite differently. RepGrid2 allows the researcher to **compare individual grids**, but in order to do that, the constructs and elements in all the grids must be exactly the same, even down to capitalization. Thus, it is not possible to meaningfully compare grids in which respondents have generated constructs in their own words, since these are idiosyncratic in form, if not in underlying concepts.

    For this reason, a new set of 5 respondents were chosen. The constructs elicited from the first 5 were edited by the researcher to provide a representative range of construct-pairs. These, along with a slightly reduced list of 10 elements were presented to this new group of respondents. In other words, this group did not go through the elicitation process. All they had to do was rate the elements using the "harvested" constructs. The resulting grids could then be compared two-by-two to show similarities and differences between the respondents.

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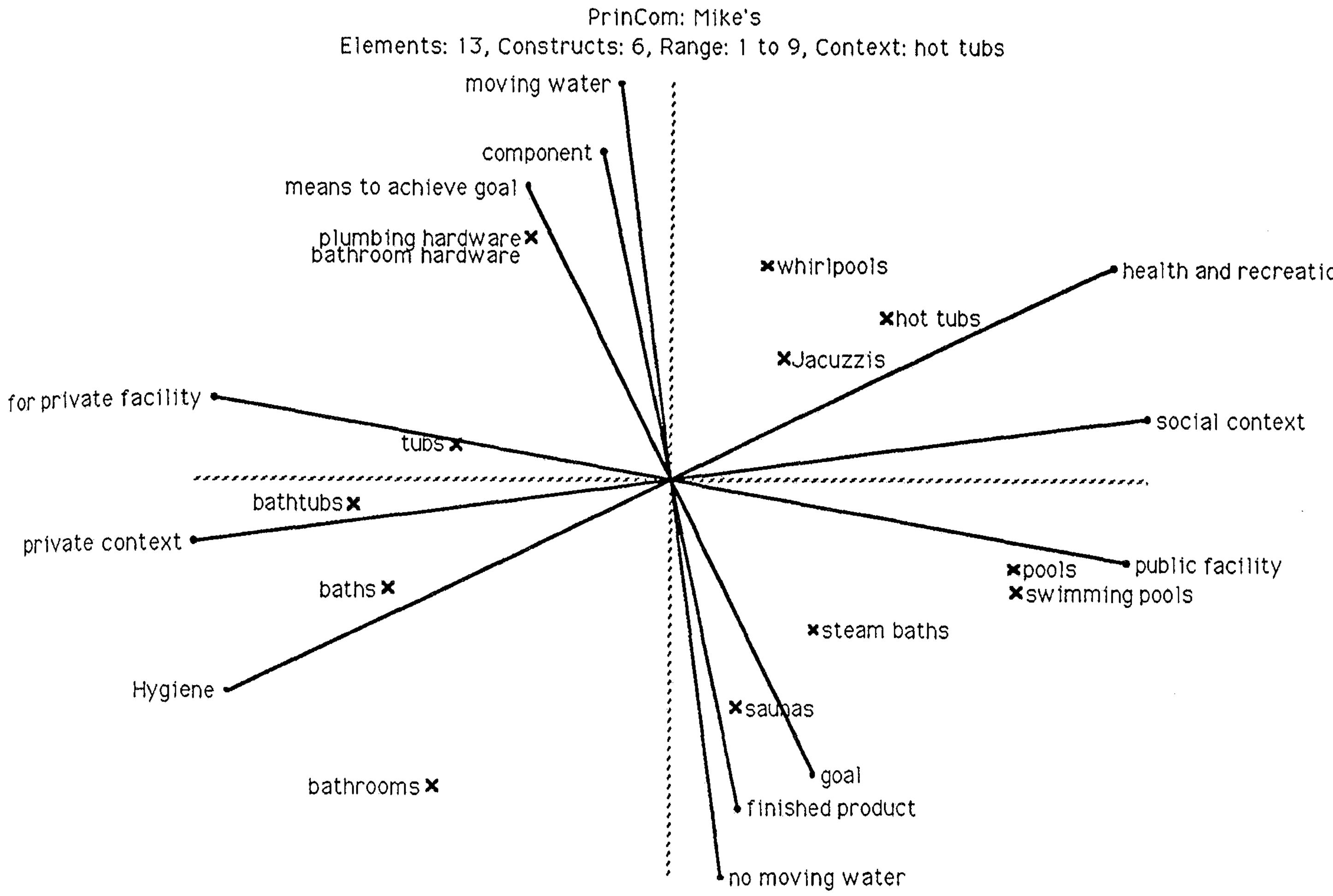

Fig. 8. Principal components graph for one respondent's perception of elements and constructs.

Figs. 9 and 10 show how one respondent's (Sue's) responses compared with two others (Bob's and Tom's). Fig. 9 shows a very low degree of agreement between Sue and Bob at the threshold set by the researcher. In fact, in terms of constructs, the two agree only on whether an element *holds water* or *doesn't hold water*. As far as elements go, Bob and Sue do not agree on any elements whatsoever. That is, they did not rate any elements similarly enough using the constructs to say that they "construe" these elements in the same way. In the case of thesaurus maintenance, if these two were in fact experts, we would say that there was a deep division in the way in which a term was being used — two experts view it as essentially two completely different entities.

Fig. 10 shows a much higher level of agreement between Sue and Tom. They agree on at least five construct-pairs and the three elements that are the subject of the study. Not only does the repgrid show how they agree, but it also demonstrates where they most disagree. So, for instance, we see that they least agree on which elements have *"moving water" vs. "still water."*

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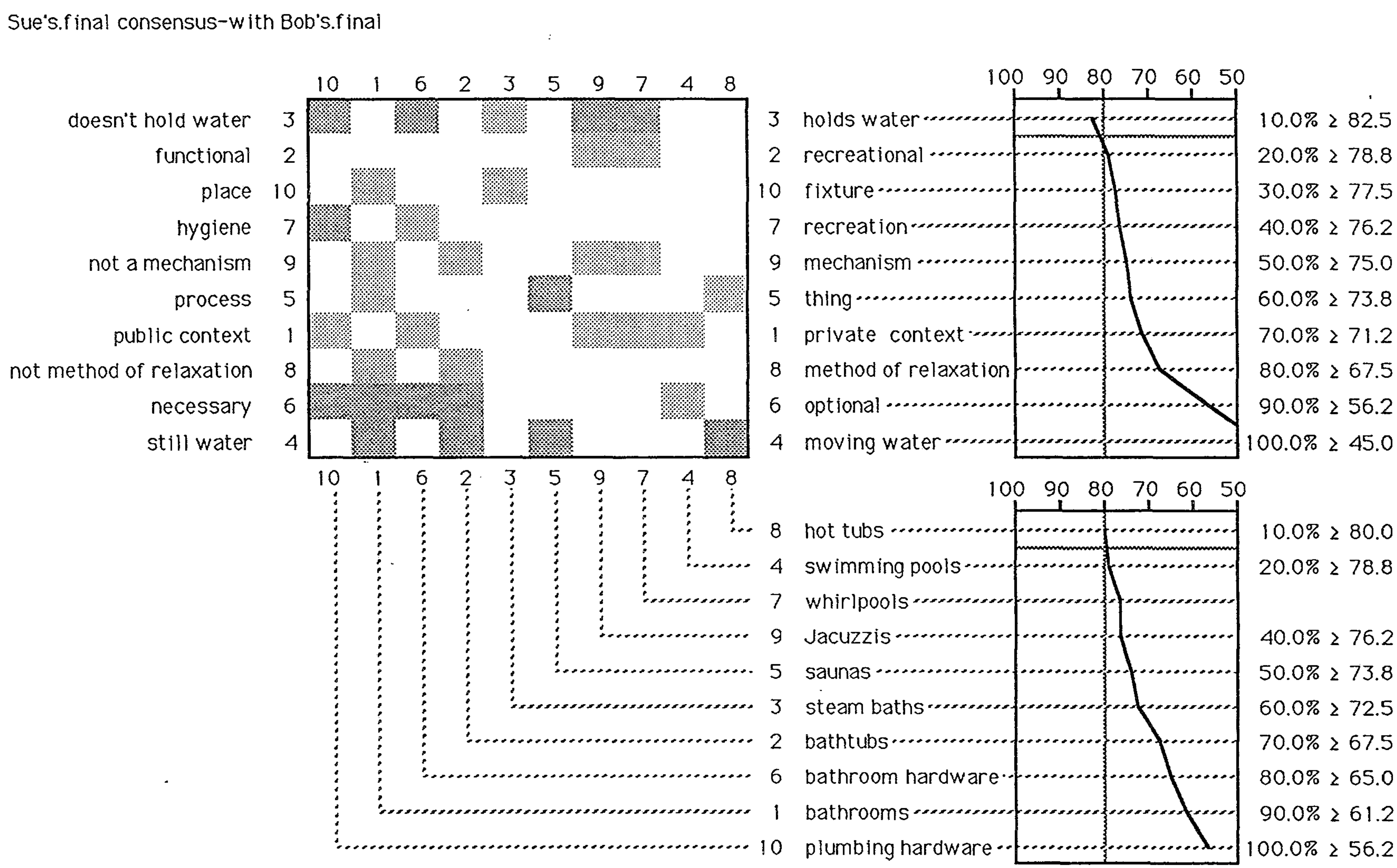

Fig. 9. Comparison of two respondents' repgrids (Sue's and Bob's).

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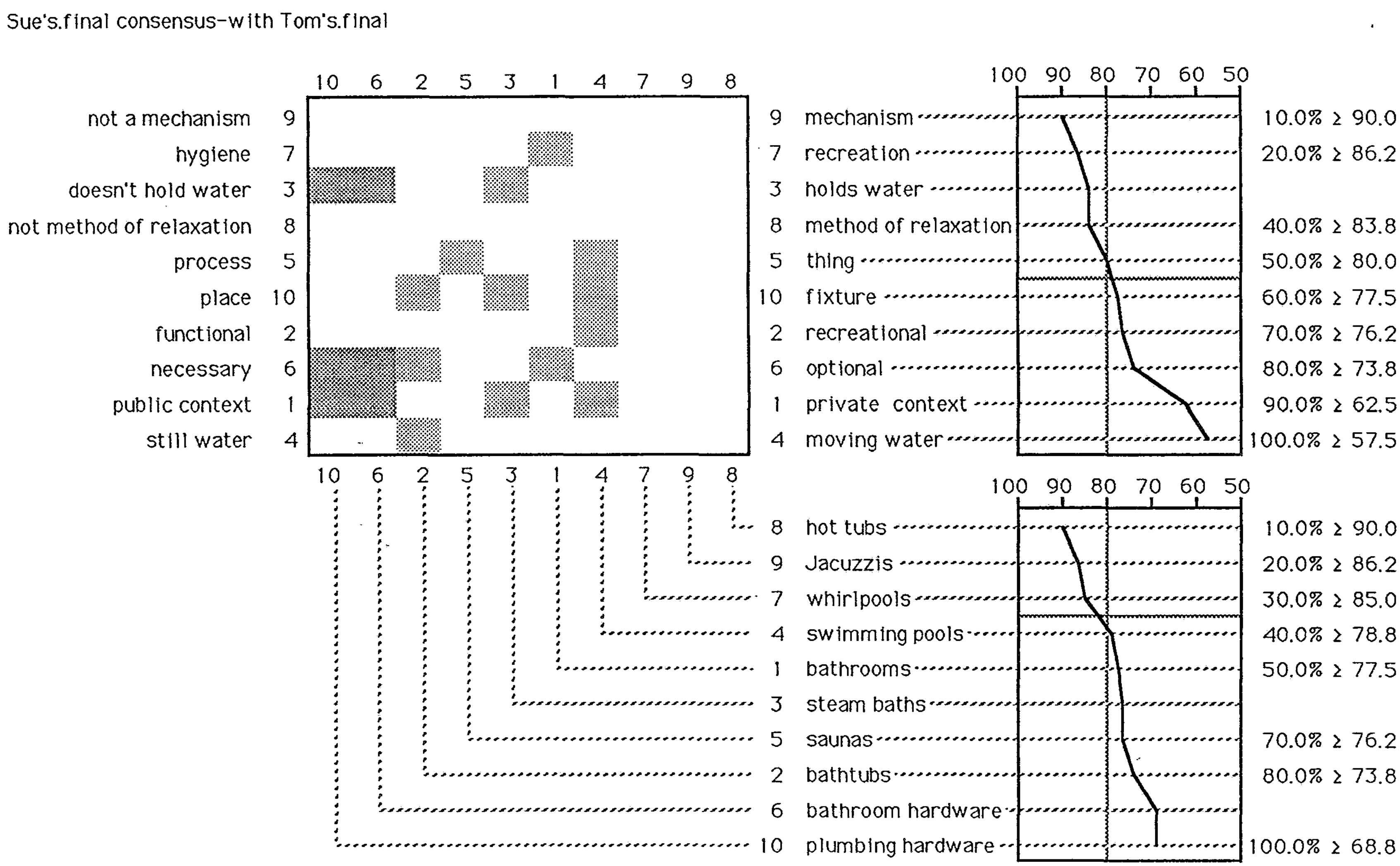

Fig. 10. Comparison of two respondents' repgrids (Sue's and Tom's).

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CONCLUSIONS

How well did the repgrids work? While this study was too small to be able to make any confident recommendations about where to put the hot tubs, it did point up the need for some sort of deeper analysis of personal constructs with respect to terminology. Overall, there were no cases in which two respondents agreed 100 percent with respect to any elements or any constructs. In addition, there was a great deal of disagreement, or perhaps we might call it individuality, in the way in which even seemingly common elements (such as a bathtub) were construed. Some of these disagreements can be attributed to cultural differences (the notion of private baths in the U.S. *vs.* public baths in Europe or Asia, for instance), but some are what we can expect from any set of people given the great variability of our language and the personal perspective that each of us brings to bear on our environment (Furnas, et al., 1987; Kwasnik & Jorgensen, 1992)

What the repgrids were able to do is to tease out the subtle differences among the respondents. It would still be a matter of qualitative assessment to judge whether the criteria by which any two people agree or disagree are critical to the environment in which the issue is being resolved. For instance, would the fact that two people disagree about whether something has moving water or not make a tremendous difference in the case of a given term's syndetic structure. On the other hand, if two people fundamentally agree on trivial aspects, but differ on an important one (say, that a *swimming pool* is more a recreational *place* rather than a *mechanism*), then repgrids are very useful for pinpointing that area of disagreement and perhaps even suggesting alternatives.

Repgrids have some drawbacks. They can be tedious to administer. Furthermore, respondents are rating things in a vacuum rather than in the context in which these elements might be disambiguated by a specific use or purpose. Finally, repgrids do not distinguish between important and trivial distinctions. These are left to the researcher to analyze. The repgrids are a visualization tool and in that respect they provide very useful suggestions for where to focus further investigation.

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Elicitation Techniques for Classification Research: Part III. Q Methodology

Chatpong Tangmanee

A process to elicit knowledge from participants, Q Methodology is a significant research tool used to discover accurate information in a subjective domain. For example, abortion is such a sensitive and controversial issue that researchers have a hard time obtaining reliable information from participants. Untrue information may be obtained because the participants, in a focus group for instance, are among others who all have opposite ideas. A study of system analysts' attitudes toward their responsibility in system development is another application of Q Methodology. Such attitudes or viewpoints are difficult to trace by using techniques such as questionnaires. Besides, Q Methodology has also been used in classification research as well. Four groups of grazers: television viewers who use a remote control repeatedly while watching television, for example, were classified into four categories using Q Methodology (Suzanne, 1994). They are (1) the Polite group, (2) the Hungry group, (3) the Restless group, and (4) the Strict group. Despite the small number of classification research applying the technique, it is shown that Q Methodology is an effective tool used to identify attitude differences (Dos Santos & Hawk, 1988). Therefore, this paper aims to elucidate Q Methodology and its contribution to classification research.

1. DEFINITION

Q Methodology is a systematic and scientific means to examine individual opinions, perceptions, or in simpler words, individual subjectivity (Katzer et al., 1991; Kerlinger, 1986). The technique has participants expressing their subjective viewpoints by sorting cards. Because of the sorting process, the technique may be called a Q-sort.

2. SIGNIFICANCE

To give readers ideas of how significant Q Methodology is, an example of a small scale case is presented. Suppose we wish to explore managerial attitudes in solving administrative problems of a hospital. Fifty possible solutions are written on cards, one solution per card. Five participants, a, b, c, d, and e, are asked to judge how much they agree with the solutions on the fifty cards. They are asked to sort the cards into the following distribution. Each pile is assigned a value depending on the degree of agreement (10 for "most agree" and 0 for "least agree").

Pile No	11	10	9	8	7	6	5	4	3	2	1
Value assigned to each pile	10	9	8	7	6	5	4	3	2	1	0
Maximum no. of cards per pile	2	3	4	5	7	8	7	5	4	3	2

Most agree — Least agree

Figure 1: Distribution into which participants are instructed to sort fifty cards

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Some sample resulting values are given in Table 1. The figures in the five columns under a, b, c, d, and e are the value assigned to the cards, or in fact the solution statements written on the cards, in the eleven piles after five participants had sorted cards. The correlation coefficients among five participants are presented in Table 2.

	Participants				
Card #	a	b	c	d	e
1	2	4	10	5	9
2	4	5	6	0	8
:	:	:	:	:	:
13	5	4	5	5	9
14	0	3	0	1	0
:	:	:	:	:	:
25	9	6	5	8	4
26	8	6	4	7	6
:	:	:	:	:	:
37	4	1	4	7	7
38	2	6	3	1	5
:	:	:	:	:	:
49	0	8	2	3	3
50	5	0	3	5	4

Table 1: Selected data of five participants' results of sorting cards.

Even though the correlation coefficients in Table 2 need more interpretation, we can see that persons a and b agreed on the same solutions (r=0.37). So did persons c and e (r=0.48). Person d's solutions were quite different from the others as seen in the low correlation coefficient.

The Q-sorts suggested that there were two different types of participants who corresponded in their assessing of solutions of hospital problems. The first type had the same ideas as a and b, called type-A, and another type had those as c and e, called type-B.

Q Methodology can be used further to characterize features of both types. By examining the cards with which type-A's highly agreed and those highly agreed on by type-B's, type-A's seemed to solve problems by attempting to cut all unnecessary costs, whereas type-B's apparently recover the

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	a	b	c	d	e
a	--				
b	.37	--			
c	-.04	.29	--		
d	.01	-.13	.02	--	
e	.04	.10	.48	.07	--

Table 2: Correlation coefficients among participants from Table 1

situation by trying to improve the hospital's productivity. Here are solutions highly agreed on by type-A's and type-B's respectively:

Solutions highly agreed on by type-A's:

- Redefine hospital's mission statements and make operational decisions based on the statements
- Redistribute staff's responsibilities
- Evaluate business processes at the hospital and redesign them accordingly

Solutions highly agreed on by type-B's

- Reduce staff and alternate employees from clinics to the hospital
- Hire a management consultant
- Close off-site clinics and replace with shuttle bus service
- Create more out-reach programs and close in-house clinics

This example presents the significance of applying Q Methodology to classify participants' subjectivity during group decision making.

3. OPERATION

Here is how the technique works. Participants are asked to sort cards, on which statements expressing individual opinions or viewpoints are written, into several piles. Each pile indicates how much the participants agree with statements on the cards. Thus, if there are eleven piles, the first pile may be for "least agree" cards, and the eleventh pile will be for "most agree" cards. The number of cards depends on whether the cards can represent all possible opinions concerning the topics. If we are to study system analysts' attitudes toward information system development, for instance, the cards should represent all possible attitudes in this field. The opinions or statements written on cards are gathered using various techniques. They may be from literature in the field of study, from focus groups, and other kinds of interviews with a targeted population, or from personal experience. The number of cards will typically be from 40 to 150 (Kerlinger, 1986; Stephenson, 1953).

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For statistical purposes, participants are instructed to sort the cards into piles, which then make up a normal or quasi-normal distribution. If there is a total of ninety cards, for example, the possible number of cards in eleven degrees of agreement then would be as Figure 2, in order for all cards, when sorted, to be normally distributed.

Pile No	11	10	9	8	7	6	5	4	3	2	1
Value assigned to each pile	10	9	8	7	6	5	4	3	2	1	0
Maximum no. of cards per pile	2	5	7	10	13	16	13	10	7	5	2

Most agree   Least agree

Figure 2: Distribution into which participants are instructed to sort ninety cards

In an actual experiment, participants are given a pile marker which is similar to Figure 2. Participants then know, from the pile marker, the maximum numbers of cards they can place on each pile. For example, from Figure 2, a maximum of two cards can be placed on the left most pile, and both cards represent the statements with which the participant most agrees.

The actual sorting of cards is further broken down into phases to help with the sorting process. Participants first sort all the cards into three preliminary piles. The sorted cards on the left pile are the statements with which the participant most agrees. Those cards on the right pile are statements with which the participant least agrees. The cards on the middle pile are statements about which the participant is unsure or about which she or he has a "neutral" opinion. If the participant can not place a card on either the left or the right pile, it goes into the middle one.

When finished sorting the cards into three preliminary piles, the participants are instructed to select the number of cards specified on the left of the pile marker. It is two in the case depicted in Figure 2, but might be a different number in other cases. Hence, two cards with which the participant most agrees are selected from the left pile and placed under the column labeled 10 of the pile marker. The order of these two cards is not important. Both will receive the same value of ten.

The participants are then instructed to select the number of cards specified on the right of the pile marker. In the case shown in Figure 2, it is also two as in the opposite side. Hence, two cards with which the participant least agrees are selected from the right pile and placed under the column labeled 0 of the pile marker.

Each participant continues in this way, alternating between the left and the right sides, placing the specified number of cards below each column marker. They are allowed to move any card at any

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time if they change their mind about the statements on the cards. The most important part is the right number of cards found beneath each column marker. When a participant completes sorting thirteen cards, it may look like Figure 3.

Pile Marker	1 (4)	3 (3)	5 (2)	3 (1)	1 (0)
	#3	#2	#12	#8	#1
Card #		#11	#7	#10	
		#9	#5	#13	
			#6		
			#4		

Figure 3: Possible final outcome when a participant finishes sorting thirteen cards

3.1 Structures of Q-Sorts

There are two major structures of Q-Sorts: unstructured and structured Q-Sorts.

Unstructured Q-Sorts. An unstructured Q-Sort is a set of cards consisting of statements on a single topic. The cards are generated without regard to a preconceived theory or a structure in order to guide the selection of statements on the topic. For example, fifty cards in a study of homosexuality could be generally developed. A researcher would simply like to investigate general issues of homosexuality, rather than to focus especially on a moral issue or an institutional value of the topic. Most Q Methodology studies were completed in this manner (Kerlinger, 1986). A large number of statements are built in from various sources. When unstructured Q-Sorts are used, researchers must ensure that all statements are a representative of the population. For instance, 38 statements in the study of system analyst's attitude toward system development must best represent all possible attitudes that might commonly exist. Of course, it is very difficult to include all possibilities, but the statements should be thoroughly reviewed by, maybe, experts in the fields to guarantee reliability of the generated statements.

Structured Q-Sorts. A structured Q-Sort is a set of cards consisting of statements on a single topic; however, the statements are chosen to represent one or more underlying aspects of the

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topic. For example, in a study of homosexuality (McKeown & Thomas, 1988), a structured Q-sort limited the statements to Main Effects: Direction, Dimensions, and Issues, as shown in Table 3.

Main Effects	Components
A. Direction	(a) Pro-gay rights
	(b) Anti-gay rights
B. Dimensions	(c) Moral
	(d) Civil
C. Issues	(e) Consequences
	(f) Institutional value
	(g) Behavior
	(h) Social Pluralism
	(i) Minority status

Table 3: Main effects and their components in a study of homosexuality using Q Methodology

The number of statements can be determined from the number of components and the number of replications of statements in each component. The researchers in the study decided to have three replications. Therefore, the total number of statements to be generated was 2x2x5x3 = 60. Each of them had to truly reflect a component it represented. An Anti-Moral-Behavior aspect, for example, was expressed in a sample card as in Figure 4 (McKeown & Thomas, 1988), whereas, a Pro-Gay rights-Moral-Consequence position was shown as in Figure 5.

- Just the thought of somebody participating in a homosexual act is disgusting and morally offensive

Figure 4: A sample card based on an anti-moral-behavior aspect.

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- The Biblical and moral questions raised by the issue of homosexuality are sufficiently vague to cloud the issue. Therefore, to predict dire moral consequences following from gay rights is unfair since we are not sure what is involved in the first place

Figure 5: A sample card based on a Pro-Gay rights-Moral-Consequence position

3.2 Participants

The issue of the number of participants may be confusing to those accustomed to traditional sample selection rules since, in Q Methodology, a single participant is allowed. As the single case is possible, the participant will be instructed to sort the same set of cards under different conditions. Suppose we are to explore educational attitudes of a single high school student, say Jo, for example. Jo will be instructed to sort cards, say sixty cards, for (a) what a high school education should be. Three days later, Jo will be asked to sort the cards but for (b) what in the high school Jo is currently experiencing. Jo will finish the experiment by sorting the cards, but the last time for (c) what Jo thought high school education should be when he was in elementary school. Therefore, the study has one participant sorting the same set of cards under three different conditions. The data from this sample may be shown as in Table 4. It should be noted that the analysis will remain the same regardless of how many participants there are.

Card #	Condition a	Condition b	Condition c
1	0	3	2
2	7	2	5
:	:	:	:
60	2	0	1

Table 4: Selected data of a single participant 's results of sorting sixty cards under three different conditions

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A decision on the number of participants thus depends solely upon the researcher' s judgment. However, Thompson and others (1983) suggested that the maximum number of participants be (N/2)-1, where N is the number of cards.

4. ANALYSIS

When all participants finish sorting the cards or a single one completes ranking the cards under different conditions, correlation and factor analysis are used for data analysis. The variables in Q Methodology refer to each participant, instead of each statement or each card. For example, from Figure 3, as there was only one participant sorting thirteen cards, the first column of a data matrix for the analysis would be as in Table 5. The final results of a Q-sort will be clusters of participants such that each cluster classifies all participants with similar attitudes or viewpoints.

	Participants			
Card #	1st	2nd	3rd	...
1	0	...	...	...
2	3	...	...	...
3	4	...	...	...
4	2	...	...	...
5	2	...	...	...
6	2	...	...	...
7	2	...	...	...
8	1	...	...	...
9	3	...	...	...
10	1	...	...	...
11	3	...	...	...
12	2	...	...	...
13	1	...	...	...

Table 5: A data matrix based on Figure 3.

5. STRENGTHS AND WEAKNESSES OF Q METHODOLOGY

This section is to provide readers insight into advantages and disadvantages of using Q Methodology. The technique has been criticized for its operation and analysis. Q Methodology may be considered as a qualitative technique because of its method of statement preparation and its subjective sorting procedure. On the other hand, it can be viewed as a quantitative technique for

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its analysis using Factor Analysis. Some of the strengths and weaknesses discussed here are from Kerlinger (1986).

Strengths

- Ability to test aspects of a theory
  If a theory can be categorized into finite groups, and if the expression of the groups can be generated, Q Methodology will be one of the powerful methods to investigate the theory.
- Suitability for deep study of individuals
  A single participant is allowed. This contributes significantly to deep studies of individuals.
- Ability to test the effects of independent variables on complex variables
  This is one of the possible solutions when one studies attitude change under the impact of communication, or interaction.

Weaknesses

- No well-defined concepts of the number of the participants
  Even though one participant is allowed, it limits the generalizability of the findings in other settings. No concrete evidence can be used to decide how many participants should be included.
- Statistical assumption violation
  The responses to more than one card are not completely independent from each other because those responses are from the same participant.
- Forced sorting procedure
  Q Methodology has been criticized for the sorting procedure, since participants are rigorously instructed to sort cards in a manner such that the sorted data will be normally distributed. This procedure is not entirely intuitive for participants in order to apply Factor Analysis, which is the statistical tool underlying Q Methodology (see detailed explanation in Stephenson, 1953; Rummel, 1970).

6. Q METHODOLOGY AND ITS APPLICATION IN CLASSIFICATION RESEARCH

As introduced by William Stephenson (1953), a professor of Communication, Q Methodology has gained wide acceptance in various fields such as communication, psychology, education, and political science. However, the technique has also been implicitly applied in the field of classification.

Turley (1991) applied Q Methodology to study competencies of software engineers. Five competencies for exceptional software engineers emerged: (1) helps others, (2) proactively attempts to influence project direction by influencing management, (3) exhibits and articulates strong beliefs and convictions, (4) masters of skills and techniques, and (5) maintains "big pictures" view. Meanwhile, for those who are non-exceptional, four competencies were classified as: (1) seeks help from others, (2) responds to schedule pressure by sacrificing parts of design process, (3) driven by desire to contribute, and (4) willingness to confront others.

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A study of system analyst's attitudes toward information system development is another example of applying the technique in classification (Dan Santos & Hawk, 1988). Using Q Methodology to study the attitudes, three groups of the analysts were classified: (1) those who focus more on user needs and are less concerned with technical aspects, (2) those who focus more on technical aspects and on management concepts, and (3) those who focus more on the socio-political aspects of information system development. In addition, some factors affecting each group were identified using Q Methodology as well. For instance, extensive reviewing users' needs and frequently monitoring a project were two of the most concerns of the first group, whereas, addressing latest technology features was one of the factors with which the second group were most concerned.

7. CONCLUSION

An appropriate combination of qualitative techniques and quantitative methods, Q Methodology is one of the powerful tools for classification research. While other statistical methods in this field are mostly for analyzing objective data, Q Methodology provides researchers an accurate technique: a sorting procedure, for collecting subjective data as well as rigorous methods: correlation and factor analysis, for investigating those data and drawing concrete conclusions. Q Methodology has been proved to be an scientific classification tool for subjective data.

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