SWP 1/94 REPERTORY GRIDS IN MARKET RESEARCH: AN EXAMPLE

DR KEITH GOFFIN

(Product Marketing Manager, Hewlett Packard)

Former Doctoral Student, Operations Group
Cranfield School of Management
Cranfield University
Cranfield
Bedford MK43 OAL
United Kingdom

Tel: +44 (0)234 751122
Fax: +44 (0)234 781806

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The aim of this paper is to give an example of how repertory grid technique was used successfully to identify views on a complex topic. The information presented should be useful to researchers considering using the technique themselves. For readers unfamiliar with repertory grids the two papers "*An introduction to repertory grids - parts one and two*" by Smith (1986[a],[b]) are highly recommended. These explain the basic method, data analysis and the terminology used in this article.

Research Goals

The goals of the research project where repertory grid methodology was used were:-

1) To identify the attributes of good product support (from the perspective of medical customers).

2) To identify the most important attributes.

3) To identify how various products and services offered by different medical companies compare.

In total, sixty-five interviews using repertory grid technique were made, enabling the above goals to be reached. In the author's opinion, other techniques would not have been so successful. Why? This brings us to the rationale behind the choice of repertory grid interviews.

Rationale for Grid Testing

Two questions need to be answered in order for readers to fully understand why repertory grid technique was chosen:-

- Why was (structured) interview technique chosen as opposed to other survey methods?

- Why was repertory grid methodology chosen as the most suitable interview technique?

A number of preliminary (unstructured) interviews were made with customers from the medical market. The experience from these led to repertory technique being chosen and therefore indirectly provided the answers to the above questions.

Interview technique was chosen because of the complexity of the topic. The preliminary interviews showed wide variation in customers' understanding of the scope of product support. It was therefore clear that postal or telephone surveying was not a suitable approach - the chance for misunderstanding was too high. It was also essential to structure the

interviews, since the goal was to collect the same set of data from each interviewee.

Once structured interviewing had been chosen, a form had to be developed but *why* was the repertory grid method chosen? A simpler form of structured interview could have used a pre-defined set of direct questions. However, questioning customers directly for their views on support was rejected after the experience of the preliminary interviews. In some of these, direct questions such as, "*What are the most important aspects of product support to you?*" often prompted the interviewee to reply with a question himself - typically: "*What exactly do you mean by product support?*". Any answer from the interviewer to this question (e.g. along the lines of, "*Product support is installation, training, maintenance, repair, etc.*") would bias the interviewee's subsequent answers. Therefore, it was necessary to choose a methodology which can be used to collect unbiased data on a concept not necessarily fully understood by the subjects. The repertory grid interview fitted this requirement well - "*The* [repertory grid] *interview, with its potential for subtle interactions and its concern with the interviewee's understandings, is a fruitful context in which to explore people's concepts*" (Brenner et al, 1987).

The interviews were designed to meet the aims of the research and to match the special characteristics of the medical market. This required modification of the normal form of the rep-test used in market research. To understand why, readers will require some background details.

Relevant Characteristics of the Medical Equipment Market

Three main aspects of the medical equipment market influenced the design of the research:-

- The different types of customer and their involvement with equipment
- The wide range of equipment used in hospitals
- The importance of product support in the medical market

The main types of "customer" in the medical equipment market are administrators, doctors, nurses and hospital *biomedical engineers*. Hospital administrators have a strong role in the purchase of new equipment and look for cost-effective, reliable products. However, they have little involvement with equipment once it is in use. Most hospital equipment is operated by either doctors or nurses and they generally have the biggest influence over what is purchased. Normally they are involved with a limited range of equipment; that used in the departments in which they work. In addition, doctors and nurses are not involved with all aspects of product support. For instance, they have virtually no knowledge of how equipment is maintained

or repaired. Biomedical engineers usually have experience with the full range of equipment at a hospital, typically that from various manufacturers. They are involved with all aspects of support, as they carry out many of the maintenance, repair and training tasks related to equipment in a hospital. Due to their involvement in all aspects of product support, biomedical engineers were an ideal group to interview for their views.

There are three main categories of equipment used in hospitals: *1) Diagnostic devices* (e.g. electrocardiographs - which are used to diagnose abnormal heart activity - or ultrasound imaging devices); *2) Monitoring devices* (e.g. heart and respiration monitors used in intensive care); and *3) Therapeutic devices* (e.g. ventilators to assist patients' breathing, infusion pumps to administer drugs). Hospital equipment is based on a wide range of technologies. For instance, monitoring equipment consists largely of electronics which measure patient signals, whereas ventilators have complicated mechanical parts. Most hospitals have equipment from a wide range of suppliers but they may standardise on one manufacturer for certain types of equipment (e.g. monitors). Most types of equipment are used for 7-10 years before replacement. Larger and university hospitals tend to use a full range of equipment, including the most modern and complicated products.

Good product support is very important in the medical market. Product reliability plus, when necessary, quick repair is essential for obvious reasons - equipment is often used in critical care situations. Most equipment manufacturers have their own customer support organizations, who offer services such as quick response in the case of equipment failure and detailed training for the operators of equipment. These organizations work closely with hospitals' biomedical engineers. Due to the importance of product support in the medical market, it appeared a suitable market for exploratory research.

B) REPERTORY TEST DESIGN

In the normal form of repertory grid interview used in market research, subjects' views are identified by asking them to compare different pre-chosen products (these are termed the *elements* of the test). In an investigation of the attributes of consumer products, the elements would be ten or more brand names, well-known to the subjects, each written on a card (Frost and Braine, 1967). Groups of three cards (*triads*) are selected and presented to the subject who is asked to compare them. His explanations of why two of the brands are similar and different from the third are his *constructs* - the attributes on which he differentiates between brands.

For the research into medical customers' attributes of good product support, a slightly different approach was required to that normally used in market research. This was because different hospitals have different ranges of equipment from different manufacturers. Therefore it was not possible to

use an identical set of elements, well-known to the sample of biomedical engineers. Consequently, subjects were allowed to chose their own elements. (This approach is more similar to the original repertory grid method used in psychology.) Subjects named medical products from different categories of equipment and different manufacturers. Comparing products from different manufacturers would, it was hoped, identify constructs on product support related to both the products themselves and to their manufacturers' support organizations.

The design of the interviews was based on knowledge gained from a review of the literature (details in Goffin, 1992, p322) and three pilot interviews. These pilot interviews were essential to see how the test performed in the market of choice and enable improvements to be made before the actual interviews took place. To understand all aspects of the rep-test design eight points need to be discussed, ranging from the choice of the sample to the data collection tool.

1) Choice of the Sample

As explained, biomedical engineers were seen as the most appropriate "customers" to interview, because of their knowledge of many aspects of support. In addition, they have involvement with more equipment (c.f. doctors and nurses) and so it was easier to *elicit* a suitable number of elements from them. Since the research was exploratory, no attempt was made to achieve a representative sample of biomedical engineers.

2) Stages of the Interviews

There are many variations on the form of the repertory grid interview. Smith (1986[a]) identified six main stages, including the post-interview data analysis. Based on this, the five stages in the actual interviews were:-

1) Explanation of the test to the subject.

2) *Elicitation* of the subject's elements. Each product named was written on a separate card.

3) Presentation of the triads to the subject. For each triad, one or more constructs was elicited. (When new triads stimulated no new constructs, or if the interview lasted much longer than one hour, the test was terminated.)

4) After each construct was elicited, all ten elements were rated against it using a 1-9 scale.

5) After the last construct, background information on the role of the biomedical engineer was collected.

3) Choice of the Elements

Ten personal elements were elicited from biomedical engineers. A total of ten elements was chosen for two reasons:

> 1) To to allow a suitable number of triads to be selected from the total number of elements. (From a total of ten elements, 120 triads can be selected. Note, however, these include many *sequential triads*, in which only one element is changed - these have a disadvantage which will be explained later.)
>
> 2) To allow the biomedical engineer to select a suitable range of the products of which he had knowledge.

No restriction was made on the type of products chosen by the subjects or the number of different manufacturers amongst the elements. This had the advantage that the subjects were often presented with triads of three very different products and technologies - for instance a ventilator being compared with a monitor and an infusion pump. When subjects have to compare very different elements, this has the advantage that they tend to identify more important constructs (Bender, 1974).

Each subject chose his own elements since, as mentioned, it was not possible to define a common set of elements for all subjects. (This is a big difference to the situation in consumer research, where often subjects will have experience with a same range of brands[1].)

4) Selection of the Triads

Each of the ten products named by the biomedical engineers was written on a separate card. The order in which the products were named determined which card number was assigned. (For instance the first element named had been randomly pre-assigned the *Card number* 5. The order of the elements and their corresponding card numbers are above the repertory grid - see Figure 1.)

The card numbers were used to pick the pre-determined triads that would be presented to the subject. Table 1 shows the pre-defined triads. Note that at least two elements are changed between any two subsequent triads. This is because subjects may give less important constructs when they are presented with a subsequent triad with only one new element: "*The sequential form ... only changes one element in each triad; thus, if the new element is not striking for the subject, since he is not allowed to repeat himself, he is forced to give a less important construct*" (Bender, 1974). The triads presented to different subjects consisted of equivalent combinations of card numbers but were not identical, since each engineer named different

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[1]Another big difference is that consumers regularly buy products and so are likely to have knowledge of competitive brands, gained from comparisons made before a recent purchase. Since medical equipment is typically only replaced after 7-10 years use, medical customers seldom have up-to-date knowledge on the range of products on the market.

elements.

In consumer research, subjects may be given additional stimulation to the brand names, for example product photographs may be used on the cards (Frost and Braine, 1967). This was not possible as biomedical engineers named their own elements.

Table 1: The first nine pre-defined triads used (note that at least two elements are changed between subsequent triads).

Triad	Card Numbers
1st triad	1, 2, 3
2nd triad	4, 5, 6
3rd triad	7, 8, 9
4th triad	1, 2, 10
5th triad	3, 6, 9
6th triad	2, 5, 10
7th triad	3, 5, 7
9th triad	4, 5, 9

5) Handling of the Constructs

Typically ten constructs were elicited during interviews with biomedical engineers. When a construct was not clear to the interviewer, extreme care was taken to understand its meaning, without biasing the test. In general though, the meanings of the constructs were immediately clear and they were directly immediately onto the grid.

6) Rating of the Elements

The elements in the test were rated on a scale of 1 (good) to 9 (poor). Various scales have been used in repertory grid testing including a simple dichotomous scale. The choice of the number of points on the scale is situational - if the respondents are sophisticated they can deal with more complicated scales (Pope and Keen, 1981). In the case of interviews with biomedical engineers ten elements were being rated and so the possibility that an engineer would discriminate between almost every element had to be accounted for. Initially the common 1 to 5 scale was used but rejected after the pilot interviews. In these, subjects commented that the rating scale was not wide enough. Support for a wider scale can be found in the literature: "*An eleven-point scale, rather than the more usual five, seven, or nine-point scale was chosen to present greater opportunity for discriminatory judgements*" (Hudson, 1974).

7) Explanation to the Subject

The way in which the test was explained to the subject was very important -

because the potential for misunderstanding was high, as was the potential to bias the results. Therefore, the subjects were informed of the purpose and format of the test as follows:-

Interviewer. I am from the marketing department of Hewlett-Packard Medical Products. I am Technical Marketing Manager for monitoring products and am responsible for deciding how our products will be supported. This includes deciding what services we offer to customers after they have purchased our products. We are conducting a survey to determine which factors about our products are important for biomedical engineers. As part of this, I am interviewing a number of biomedical engineers to ask their opinions on various products and, as you were told in advance, I would like to interview you.

The interview will last approximately one hour and, if you have nothing against it, I would like to record it - then I will not have to take so many notes. The recording will only be used to produce a transcript of the interview. Do you mind if the interview is taped?

Subject. {Gives answer}[1]

Interviewer. The type of interview that we are using for the survey of biomedical engineers is standardised, so that we can compare the results. It involves discussing different products that you have in this hospital and has two stages.

For the first stage, I would like you to name ten medical electronics products used in your hospital and with which your department has experience. I will write the name of each piece of equipment on a separate card [Writes the name of each product on a card and keeps the cards in the order in which the products were named. Cards are then numbered, using the prepared random number process. The cards numbered 1 to 3 are selected.] Now I am going to show you three cards. Please think about these three products and how two of them are similar, from your point of view as a biomedical engineer, and different from the third.

Subject. [Splits the three cards into two similar and one different.] {Gives Construct 1}[2]

Interviewer. You decided that two of the products were similar to each other, from the support standpoint, and different from the third in that ...{construct}. Now, as the second stage with these three products, I would like you to rate these products on a scale of one (which is good) to nine (which is poor) [places an extra card with the scale of 1 to 9 written on it in front of the subject]

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[1]All biomedical engineers agreed to the interview being recorded.

[2]At this point an additional comment was occasionally required to reject trivial constructs. For instance some triads stimulated the subjects to say *"These products have different uses: therapy, monitoring and..."*. This type of construct was rejected by the statement *"Yes, they are different types of equipment but how does this influence your work as a biomedical engineer?"*

Subject. {Rates the cards in the triad}

Interviewer. Now let us sort through the other cards and rate them on the same scale, for their {Construct 1}. How does this product [shows another card] compare to {Construct number 1}? And this card [shows next card]? ...

Interviewer. Now we will consider another group of three cards. How are two of them similar, from the support standpoint, and yet different from the third? Remember that you have already identified an/(several) important support point(s): [Reads previous constructs]. Can you give another support characteristic for these three cards?

8) Data Collection and the Repertory Grid

The data collection tool (shown in Figure 1) was designed to facilitate the collection of error-free data. The grid is ten elements wide and has a length dependent on the number of constructs elicited - the blank form has space for up to thirteen constructs.

Over the grid are the pre-assigned random numbers for the elements. For instance, the first element elicited was given the *Card number* "5", whereas the second was given "1". The card numbers enabled triads to be presented to the respondent which were not simply the same as the order in which he thought of the products (*Order of personal element*). The reason for this is that subjects in the pilot interviews often named similar products (e.g. ventilators) one after another. Therefore, if the triads were based simply on the order in which the elements were elicited, then the first triads would have compared very similar elements.

The grid was designed with wide margins which left enough space for additional notes, such as quotes from the engineers about particular products or services. All interviews were recorded using a portable tape recorder. This enabled the researcher to concentrate fully on accurately determining constructs and ratings but at the same time accumulate the subjects' detailed comments on products and manufacturers' support organizations. A number of background questions were, for example on the size of the subject's hospital, the answers were recorded on the back of the grid.

C) THE RESULTS OF AN EXAMPLE INTERVIEW

Interviews with biomedical engineers successfully identified constructs related to product support. One typical interview (with subject B11) will be discussed, including the elements and constructs, statistical analysis of the ratings and the cognitive map - a representation of the subject's perception of product support.

Respondent B11 was supervisor of a three-man biomedical engineering department at a 200 bed hospital. This department is

responsible for equipment maintenance, repair and training of medical personnel.

1) The Elements

Respondent B11 named the ten products shown in Table 2 as his personal elements. These are patient monitors, infusion pumps, a ventilator and four other types of equipment. The broad range of equipment nominated as elements by Respondent B11 was typical of the interviews with biomedical engineers. This reflects the fact that biomedical engineering departments are normally responsible for many different types of equipment. Note that the elements in Table 2 are listed by the assigned "Element Number" (a randomly assigned number) and not the order in which they were named.

Table 2: The Personal Elements from Respondent B11 (ten different pieces of medical equipment from nine manufacturers).

	Personal Elements
1)	Company A* Patient Monitor
2)	Company B* Electro-Surgery Device
3)	Company C* Infusion Pump
4)	Company D* Anaesthesia Machine
5)	Company E* Patient Monitor
6)	Company F* Incubator
7)	Company C* Micro Infusion Pump
8)	Company G* Patient Monitor
9)	Company H* Heated Bed
10)	Company J* Ventilator

*Note: the actual medical equipment manufacturers' names were given by the interviewees but changed in this report.

2) The Constructs and Grid

The repertory grid from the interview with Respondent B11 is shown in Figure 1. The first triad of products presented to the respondent was Elements 1, 2 and 3 and these stimulated Construct 1: "*Amount of Periodic Maintenance Necessary*"[1]. All ten elements were rated against this construct and the values are shown in the grid (on a scale of one to nine). Those elements which were included in the triad are indicated by the rating being enclosed by stars (e.g. the rating of Element 1 is shown as *1*).

[1]This and all other quotes are taken from the audio tape of the interview. They illustrate that the subject's explanations of his constructs were comprehensive and unequivocal.

Figure 1: Repertory Grid for Biomedical Engineer B11

Order of Personal Element	1	2	3	4	5	6	7	8	9	10	
Element (Card) Number	5	1	8	6	9	10	4	7	3	2	

REPERTORY GRID FOR BIOMEDICAL ENGINEERS

	THE PRODUCTS (ELEMENTS) BY CARD NUMBER										
PERSONAL CONSTRUCTS	1	2	3	4	5	6	7	8	9	10	
1) Periodic Maintenance Necessary	*1*	*2*	*4*	3	1	4	4	1	1	3	
2) Ease of Repair	5	1	5	*5*	*5*	*5*	1	1	1	5	
3) Ease of Cleaning (decontamination)	4	4	3	5	3	6	*3*	*3*	*4*	6	
4) Ease of Training Users	*2*	*5*	2	7	5	4	2	2	2	*6*	
5) Availability of Spare Parts	2	3	*1*	3	3	*6*	1	2	*3*	6	
6) User Training from the Manufacturer	?	*3*	1	2	*8*	3	1	?	5	*3*	

	1	2	3	4	5	6	7	8	9	10	
7) Service Documentation	5	2	*1*	5	2	*7*	1	2	3	*7*	
8) Contact to Manufacturer	3	4	*1*	2	*5*	3	*1*	5	2	3	
9) Repair Costs	6	3	3	*7*	*9*	8	3	*8*	3	9	
10) Technical Training for Biomedical Engineers	*?*	1	1	2	5	8	*1*	?	*2*	2	
11) Material for User Training	9	9	9	9	9	9	9	9	9	9	
	1	2	3	4	5	6	7	8	9	10	

RESPONDENT:xxxxx HOSPITAL:xxxx NO. BEDS:200 NO. BIOMEDS: 3
DEPT.RESPONSIBILITIES: [Repair 30%, Maintenance 10%, Training 10 %,
Administration 50%, Other (n/a) %]
DATE:8/3/91 AUDIO TAPE #:1 LENGTH OF INTERVIEW:90min

The ratings given by B11 on Construct 1 can be seen to range from one (Elements 1, 5, 8, and 9 receive this rating) to four (Elements 3, 6 and 7 receive this poorer rating). The ratings for the first triad on Construct 1 were 1, 2 and 4 (*1*, *2* and *4*) i.e. the respondent did not consider any two of these products as being the same on this criterion. He said, "*No two are the same from these three, we really have three very different types of equipment in this bunch... a patient monitor, an electro-surgery device and an infusion pump*". He then continued and identified his construct; "*But when I consider ... [pause] the amount of work that we have with each of these... [pause] we have a lot of work with the infusion pumps and electro-surgery devices. With these there are much more intensive maintenance and inspection procedures to be carried out and documented*".

The second triad (Elements 4, 5 and 6) enabled the Subject B11 to identify Construct 2: "*Ease of Repair*". Note, however, that the elements of the triad were rated identically (with *5*) although "*they are, once again, three absolutely different types of equipment*". He continued, comparing the products; "*patient monitoring is the easiest for us - we have the least trouble with it - but there is one small point of criticism: on the transcutaneous board of Company E's monitor is a small accumulator, which could be better placed so that it would be easier to exchange. The parts which need to be changed regularly, including those from Company E, should be better designed so that they are more "service-friendly". And all parts that you know will fail should be easy to access*".

Subject B11 continued during the course of the ninety minute interview[1] to produce the following further nine constructs:-

- Construct 3: *Ease of Cleaning (Decontamination)*. This construct is very important in the hospital setting, where cleanliness is obviously important. ("*A criteria is..., it doesn't affect us directly but it is a key point for the clinical personnel, is the ease of decontamination - cleaning and disinfection. With some products you have to be more careful. But you can design a product so that it is easy to clean and not a disaster!*")

- Construct 4: *Ease of Training Users*. ("*Card number 10*[2], *that requires really intensive training for the users - that leads to user errors*".)

- Construct 5: *Availability of Spare Parts*.

- Construct 6: *User Training From the Manufacturer*". ("*One thing that occurs to me as being a weak point for Company E's*

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[1]This included several interruptions due to telephone calls.

[2]In this and other interviews the subjects automatically referred to the cards by numbers rather than the name of the company and product. The researcher had the impression that this allowed the subjects to be more critical about the interviewer's own company's products as they were referred to as a card number. Whether this is the case or not requires further investigation.

monitors - it's not that bad although it is a weak point - the amount of user training provided. There we are spoilt by competitive companies. That is to say, we don't receive as much user training as we would like. For one monitor we receive one training and with sixty nurses on some units, that's not enough.")

- Construct 7: *Service Documentation.* The quality of this plays a key role in making maintenance and repair easy.

- Construct 8: *Contact to the Manufacturer.* Respondent B11 explained that this construct covered the relationships with company representatives and the quality of regular information provided for biomedical engineers in newsletters etc.

- Construct 9: *Repair Costs.*

- Construct 10: *Technical Training for Biomedical Engineers.* Respondent B11 had attended several technical seminars given by manufacturers and considered the quality of these very important for biomedical engineers.

- Construct 11: *Material for User Training.* ("*We are now beginning to instruct all new nurses and to give regular trainings for the anaesthesia department. We need better material and graphics to be able to explain the equipment simply. As a biomedical engineer your completely on your own on this one... it would be very useful to have good training material*". Note that the ratings given on this construct were all nine - the lowest possible rating as no manufacturer offered good documentation for training purposes.

Note that certain products could not be rated against certain constructs by the interviewee. For instance, Element 8 was not rated against Construct 6 (*User Training from the Manufacturer*) as the respondent had no knowledge of the training offered by this manufacturer. This is indicated on the grid by a question mark.

From B11's eleven constructs it can be seen that some are related to the product itself (e.g. *Ease of Cleaning* and *Documentation*) whereas others are related to the manufacturers' support organizations (e.g. *Contact to the Manufacturer*). This mixture of constructs is typical for the interviews with biomedical engineers.

3) Statistics for the Constructs

Statistics based on the subject's ratings give important information on the constructs. Table 3 shows the descriptive statistics for B11's constructs. For

example, against Construct 1 (*Amount of Periodic Maintenance Necessary*) the elements were rated from a minimum of 1 to a maximum of 4 and had a mean of 2.40 (standard deviation of 1.28). Construct 1 accounted for 4.54 percent of the variability of Respondent B11's ratings, across all constructs. The variability is an indication of a respondent's most important constructs (Smith 1986[b]) and so it can be seen, on this criterion, that B11's salient constructs are *Repair Costs* (17.41% variability), *Technical Training for Biomedical Engineers* (15.05% variability), *Service Documentation* (13.42%) and *User Training from the Manufacturer* (12.97%).

According to Smith 1986[b], high variability denotes the most important constructs because variability indicates constructs where the subject perceives big differences between elements. However, constructs with low variability can also be very significant, depending on their average ratings are high or low.

A low variability with a high average rating indicates a construct on which all products are highly rated. This type of construct is not the most significant - even if it is one of the first constructs identified by a subject - as it is probably not an area where a company can gain competitive advantage. An example is Construct 1, the *Amount of Periodic Maintenance Necessary* (with 4.5% variability and a mean rating of 2.40). From the ratings, it appears that maintenance of all ten pieces of equipment is comparatively easy. Therefore, although it is essential to offer easy maintenance to compete, it is not an area where a company can easily gain a competitive advantage (such items are usually termed *hygiene factors* in marketing the literature).

Table 3: Descriptive Statistics for Respondent B11's Constructs (calculated from the repertory grid using *Flexigrid 4.2* software).

Construct	Best Rating on this Construct	Mean Rating on this Construct	Worst Rating on this Construct	Spread of Ratings on this Construct	Construct's Percentage of Spread
*	Min.	Mean**	Max.	Std Dev.	Variability+
1 Periodic Maintenance Necessary	1	2.40	4	1.28	4.54%
2 Ease of Repair	1	3.40	5	1.96	10.63%
3 Ease of Cleaning	3	4.10	6	1.14	3.57%
4 Ease of Training Users	2	3.70	7	1.85	9.44%
5 Availability of Spare Parts	1	3.00	6	1.67	7.75%
6 Manufacturer's User Training	1	3.25	8	2.17	12.97%
7 Service Documentation	1	3.50	7	2.20	13.42%
8 Contact to Manufacturer	1	2.90	5	1.37	5.32%
9 Repair Costs	3	5.90	9	2.51	17.41%
10 Technical Training for Biomeds.	1	2.75	8	2.33	15.05%
11 Material for User Training+	9	9.00	9	-	----%
Average		*3.49*			

Notes:
+ Construct 11 has identical ratings for all elements.
* The headings in this line are those adopted by Smith (1986[b]), whereas the line above attempts to give titles that are easier for the reader to understand.
** The statistics in this and later tables are reproduced exactly as they are output from *Flexigrid*; the figures are not necessarily significant to this degree.

Constructs with low variability and low average rating can, however, identify important opportunities for companies to gain competitive advantage. For instance, Construct 11 has zero variability because all manufacturers score equally poorly (a rating of 9) on this point. This is clearly an area where one company could gain a competitive advantage by providing training material as one of its support services. (Obviously the perceptions are from a single biomedical engineer and the need for training material would need to be confirmed with a representative sample.)

4) Statistics for the Elements

Table 4 shows the statistics for the elements, with the best, average and worst scores, plus the standard deviations and variabilities.

Table 4: Descriptive Statistics for Respondent B11's Elements.

Element	Type of Product	Element's Best Score	Element's Mean Score	Element's Worst Score	Spread in Element's Ratings	Percentage Attributable to Product
*		Minimum	Mean	Maximum	Std Dev.	Variability
	Ideal Product	*1*	*1.00*	*1*		*0.00%*
1	Company A Patient Monitor	1	3.50	6	1.66	8.98%
2	Company B Electro-surgery Device	1	2.80	5	1.25	5.09%
3	Company C Infusion Pump	1	2.20	5	1.40	6.40%
4	Company D Anaesthetic Machine	2	4.10	7	1.87	11.39%
5	Company E Patient Monitor	1	4.60	9	2.37	18.41%
6	Company F Incubator	3	5.40	8	1.80	10.57%
7	Company C Micro Infusion Pump	1	1.80	4	1.08	3.79%
8	Company G Patient Monitor	1	3.00	8	2.24	16.32%
9	Company H Heated Bed	1	2.60	5	1.20	4.70%
10	Company J Medical Ventilator	2	5.00	9	2.10	14.36%
	Overall Average		*3.50*			

* Note: The headings in this line are those adopted by Smith (1986[b]), whereas the line above attempts to give titles that are easier for the reader to understand.

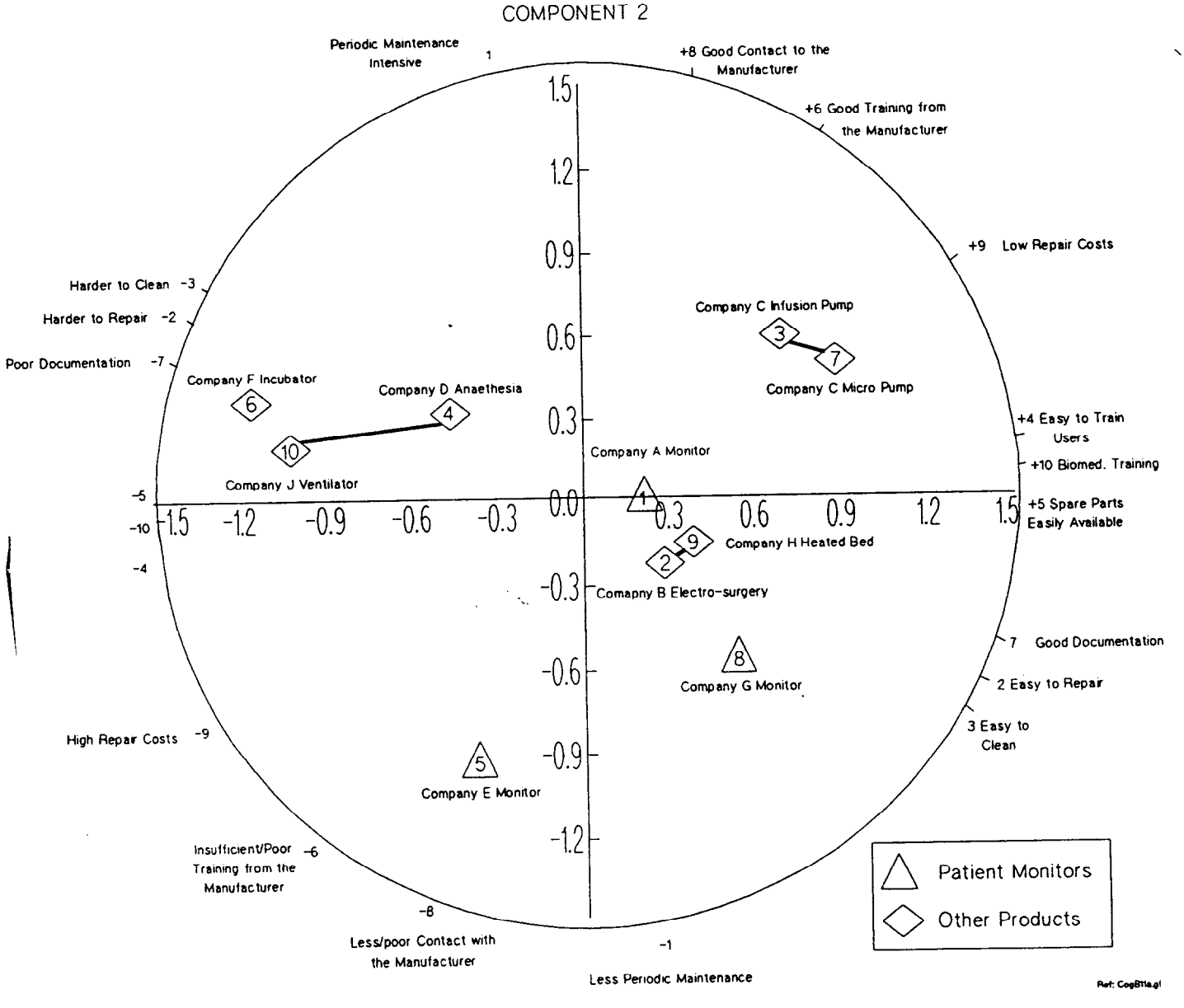
It can be seen that Element 7 (Company C's Micro Infusion Pump) has a good average rating of 1.80 and low variability (3.79%). This shows that everything about this product and manufacturer is perceived positively from B11's perspective. The product with the poorest average rating is Element 6 (Company F's Incubator) with 5.40.

Note, however, the average ratings of the elements are derived from a range of constructs - some of which are product related, some price related and some related to the manufacturer's support organization. Therefore, a rating in the mid-range could be due, for example, to a product that was well perceived but from a manufacturer with poor support services. The elements which have very good ratings on some constructs but poor ones on others can of course be recognized by their high variability (e.g. Company E's patient

monitor with 18% variability).

Figure 2: The Cognitive Map from the Example Interview with a Biomedical Engineer (Subject B11).

KEY TO PRODUCTS BY CARD NUMBER	
1) Company A Patient Monitor	6) Company F Incubator
2) Company B Electro-Surgery Device	7) Company C Micro Infusion Pump
3) Company C Infusion Pump	8) Company G Patient Monitor
4) Company D Anaesthetic Machine	9) Company H Heated Bed
5) Company E Patient Monitor	10) Company J Medical Ventilator



5) The Cognitive Map

Principle Components Analysis (PCA), allows the data in the repertory grid to be converted into what is called the *cognitive map*, which visually represents a subject's perception of the elements against the constructs. This method is explained in detail in Smith (1986[b]). Subject B11's cognitive map is shown in Figure 2 and its main features of which will be discussed.

The circle drawn from the origin of the two components is annotated with ten of B11's constructs (the eleventh construct had identical ratings for all products and was therefore omitted from this analysis). Three constructs (4, 10 and 5) have strong correlations with Component 1, whereas two (1 and 6) are strongly correlated to Component 2. This shows that the subject's perception of support is largely explained by the five constructs related to these components. In general the right hand side of the map includes the products which are perceived as good and from manufacturers with good support organizations. Three pairs of products are perceived as similar from the support viewpoint and form what are termed *clusters* on the cognitive map. These are:-

- Company J's Ventilator (10) and Company D's Anaesthetic Machine (4) - this similarity is not surprising as both pieces of equipment are of comparable complexity and have a similar medical application

- Company C's Infusion Pump (3) and Micro Infusion Pump (7) are clearly perceived as very similar and easy to support

- Company H's Heated Bed (9) and Company B's Electro-surgery Device (2) are also perceived as easy to support

Element 5's (Company E's monitor) position on the map is distinctive for B11 - this product is perceived as having high repair costs and being supported by an organization who provide too little training for the users and have too little contact with the respondent's biomedical engineering department. This, and the other products' positions, have implications for the respective manufacturers. Obviously the perceptions are from a single biomedical engineer but, if the results were confirmed from a representative sample, they would indicate areas of the support strategy that could be improved.

Similar results were seen in the other cognitive maps derived from interviews with biomedical engineers. Of course these maps cannot be directly compared to each other as both the elements and the constructs were specific to each subject. However, looking the cognitive maps from different biomedical engineers allowed key points to be identified. For instance, the high perceived repair costs of Manufacturer E could be identified in several maps as could be the poor documentation of Company F. Both these points and similar ones obviously have implications for the companies in question. Therefore, it can be seen that the cognitive map

offers a good method for companies to measure how customers perceive support and to identify where changes to their support strategy can bring competitive advantage.

D) CONCLUSIONS

The example interview discussed showed that the repertory grid methodology can be a highly successful method for interviewing on complex topics. Similar results were obtained in the other repertory interviews with biomedical engineers. Five key points emerged from the use of the repertory grid method for these interviews:-

There are many variations on the form of a repertory grid interview. Interviews need careful design and piloting, to ensure that they achieve the research goals and fit with the boundary conditions of the sample and market under investigation.

- The repertory grid method can be used to help subjects articulate their views on a complex topic, in a situation where direct questioning is liable to cause interviewer bias. Subjects were able to describe a wide range of aspects related to support, simply by comparing the products in the triads.

- The repertory grid method produces clear details on constructs - so that they are unequivocal. Explanations of the constructs were provided spontaneously by the interviewees; these allowed a detailed understanding of each biomedical engineer's views on support. Only very occasionally were supplementary questions necessary to clearly determine the meaning of a construct.

- Simple statistical analysis of the repertory grid results allows the most important attributes to be identified. The example showed well that the method enables researchers to differentiation between constructs that offer opportunities for gaining competitive advantage and those that are hygiene factors.

- The cognitive map derived from the repertory grid allows a clear understanding of how companies' products and support services are perceived. Cognitive maps are rich in data for competitive analysis.

In summary, this paper described why repertory grid methodology was chosen for investigating customers' views on a complex topic and why other possibilities were rejected. It explained in detail how the test was developed and, using an example interview, demonstrated how successful the technique

and, using an example interview, demonstrated how successful the technique was for investigating a complex concept.

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